BIM BUSINESS VALUE CREATION FOR SME ARCHITECTURAL FIRMS IN NIGERIA USING INTELLECTUAL CAPITAL DEVELOPMENT

UNIVERSITY OF
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ABSTRACT

BIM has solidified its position in bringing efficiency to the Architecture, Engineering and Construction (AEC) industry. However, the shift to its adoption and implementation in the emerging markets has brought distortion in both the business processes and environment for Small and Medium Enterprises (SME architectural) in the industry. This is due to their limited resources to absorb the initial costs associated with such a shift. The starting point for this study was based on exploring the potentials in the development of Intellectual Capital (IC) of the SME architectural firms. This is because, even if the ability of these firms to mobilise the resources is small, the strategic decisions regarding their orientation towards a higher level of intensity in IC elements are under their control, and that can be a major catalyst for the BIM success. As a result, the study is built on Lu and Sexton's (2009) Theory of Innovation in Small Professional Firms. Based on this theory, BIM adoption process is approached as a Knowledge-based Innovation which occurs with the development of four IC elements; Human Capital (HC), Relationship Capital (RC) and Structure Capital (SC) through Knowledge Capital (KC) to achieve BIM Business Value Creation (BBVC). This study investigates the theoretical link between the development of these four IC elements and BBVC in SME architectural firms in emerging markets; in this case Nigeria. The aim of the research is to use this evaluation framework to develop a viable business model for management and evaluation of the IC in SME architectural firms towards BBVC.

The study is designed in three stages, namely through empirical enquiry, analysis, and synthesis. The empirical enquiry comprises theory formulation and fieldwork data collection; theory formulation is achieved through proposing an evaluation framework using a systematic literature review on the four elements of IC. The evaluation framework constitutes a set of independent variables comprising thirteen components categorised under the four IC elements. Each component is defined by a set of indicators, and the proposition aims to find the relationship between these indicators and components of the IC and a dependent variable concerning the BBVC capability of SME architectural firms.

The evaluation framework is used to guide the collection of fieldwork data, which involves a questionnaire survey and case study interviews with a sample of SME architectural firms in Nigeria. Using multiple regression analysis on the survey data enables an evaluation of the framework. Each component and its sets of indicators represent an independent model of

regression. The outcome provides statistical evidence of the relationship between the two main variables; it also gives the Relative Weighting Value (RWV) for each indicator on the components it represents and their effects on the BBVC. The case study analysis, involving six SME architectural firms identified from the survey sample as they have relatively significant BIM capabilities, is used to triangulate the data with the survey results and provide the RWV for the components and the fours ICs. The case study analysis uses two approaches: firstly, through an exploratory study of the semi-structured interviews, which is based on themes from the 13 IC components and helps to identify the different indicators employed by firms during the BBVC. Secondly, the Eigenvector method is applied to analyse a pairwise comparison judgement where each of the components discussed in the interview is compared and their relative importance weighted. The outcome helps to establish the reliability and validity of the survey data and provide the RWV of the 13 components and four elements of the ICs.

The findings indicate that there is a significant relationship between the BBVC and the development of the ICs of SME architectural firms. This development occurs through fostering the motivation and capability of Human Capital, which is the most important aspect driving BBVC. The second ranked factor is the development of the support and capability of the Structure Capital, and the motivation and network resources resulting from the Relationship Capital. The least important aspect of the development is the resource management of the Knowledge Capital. The findings also involve the identification of the different RWV of each of the 13 components under the four Capitals, and the RWV of the various sets of indicators that define the 13 components.

The findings enable the synthesis of a Strategic Business Model (SBM) using the Analytical Hierarchy Process (AHP) concept. The SBM depicts the prioritisation of the IC elements, based on the following four levels; Indicator, Component, Capital and Organisation Goal. The SBM enables the practitioners to manage, prioritise and optimise their IC amidst limited resources through identification and evaluation of the focus area of development. Through a focus group with experts from the industry, the SBM is further validated practically on three criteria, namely; implementability, usefulness and generality. The feedback is used to refine the model and describe its practical implications.

ACKNOWLEDGEMENT

IN THE NAME OF ALLAH, THE MOST GRACIOUS AND THE MOST MERCIFUL…

First and foremost, I’d like to thank Allah (The exalted, and far is He from imperfection) who gives me the ability and wisdom to achieve this tremendous accomplishment, and so wish to sustain with full faith. Then to Prophet Muhammad (Peace be upon him) for his set exemplary path of guidance, I followed to be ethically moral to achieving such a task.

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The acknowledgement for this PhD accomplishment cannot be complete without some memories which are still fresh;

During the time of my masters in Digital Architectural Design at University of Salford, in 2012, a field I admired the most in Architecture since the days of my Bachelor studies, due to my proficiency in ICT-based practice back in Nigeria, I came across a turning point. Thanks for the then Program Director, Dr Tuba Kocaturk who would later be my PhD second supervisor. I must acknowledge her encouragement, support, perseverance and commitment in gaining confidence and motivation in developing the initial interest of PhD in the field of Digital Architecture. This turning point was on the day I would meet Professor Arto Kiviniemi for the first time, who would later be my PhD main supervisor, Professor of Digital Architectural Design, and an internationally leading expert in developing BIM, a glance at his CV was a memorable one; then I realised how naïve was my view in the world of Knowledge. Indeed, he is a symbol of accomplished personality in both academia and industry. However, the most memorable was after attending his full lectures on that faithful day, a memory still fresh to remember. I got to know so much about BIM and it makes me realised the fitness of my interest. Reflecting further then, was that curiosity on why despite the efficacy of such concept, it is still unpopular in Nigeria. This inspired me on the need to investigate the situation back in Nigeria. There and then, I started to think of research in that field. On the short-run was that immediate plan in starting to coin an MSc dissertation topic *on the subject matter. The inspiration which later transformed for a long-term motivation of a PhD studies on the subject.*

On this premise, I'd like to specially acknowledge and thank these two great personalities, Prof Arto Kiviniemi and Dr Tuba Kocaturk for their immense contribution, constant support and guidance and kindness in making this journey realistic from its inception to completion.

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GLOSSARY

AEC	Architecture, Engineering and Construction
AHP	Analytical Hierarchy Process is a method used in the study to develop the Strategic Business Model (SBM).
ARCON	Architect Registration Council of Nigeria is the regulating body for the practice of the Architect profession in Nigeria where consent was sort to carry out the study.
BBVC	BIM Business Value Creation is the measure of the capability of a SME architectural firm to reap the business benefits accorded by BIM technology, used in the study as the main dependent variables.
BIM	*Building Information Modelling a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life cycle* (Succar, 2009)
BPO	Business Process Orientation (Lockamy III & McCormack, 2004)
CAD	Computer Aided Design
CIFE HORSESHOE	A research process framework developed by the Centre for Integrated Facility Engineering, University of Stanford, USA.
CMMI	Capability Maturity Model Integration - Software Engineering Institute/ Carnegie Melon

COBIT	Control Objects for Information and related Technology – Information Systems Audit and Control Association (ISACA) and the IT Governance Institute (ITGI)
CSCMM	Construction Supply Chain Maturity Model (Vaidyanathan & Howell, 2007)
HC	Human Capital, one of the four Intellectual Capital elements
IC	Intellectual Capital is that potential resource of SME architectural firms that is formed through the development of the four elements of Human, Relationship, Structure and Knowledge capital to provide a competitive advantage in the market place.
I-CMM	Interactive Capability Maturity Model developed as part of the National BIM Standard (NBIMS) Version 1 Part 1 - a project of the National Institute for Building Sciences (NIBS), buildingSMARTalliance™
ICT	Information and Communication technology
IDDS	Integrated Design and Delivery Solutions
IFC	The Industry Foundation Classes is a data model that has neutral and open specification developed to improve interoperability of platforms for BIM.
IPD	Integrated Project delivery.
IT	Information technology

KC	Knowledge Capital, one of the four Intellectual Capital elements
KRML	Knowledge Retention Maturity Levels - (Arif et al, 2009)
LESAT	Lean Enterprise Self-Assessment Tool - Lean Aerospace Initiative (LAI) at the Massachusetts Institute of Technology (MIT)
NBIMS	National BIM Standard
NVIVO	Qualitative analysis software used for the Interview analysis for the Case study.
OECD	Organization for Economic Cooperation and Development
P3M3	Portfolio, Programme and Project Management Maturity Model – Office of Government Commerce (UK)
P-CMM®	People Capability Maturity Model v2 – Software Engineering Institute / Carnegie Melon
PM²,	Project Management Process Maturity Model - (Kwak & Ibbs, 2002)
RC	Relationship Capital, one of the four Intellectual Capital elements
RWV	Relative Weighing Value is a measure of the various elements of the Intellectual Capitals relative to each other within the same hierarchy.
SBM	Strategic Business Model is the model developed by the study helping firms to manage and evaluate the Intellectual Capital

	development toward BIM Business Value creation.
SC	Structure Capital, one of the four Intellectual Capital elements
SCMP	Supply Chain Management Process Maturity Model maturity model - (Lockamy III & McCormack, 2004)
SME	Small and Medium Enterprises
SPICE	Standardised Process Improvement for Construction Enterprises - Research Centre for the Built and Human Environment, University of Salford – (Hutchinson & Finnemore, 1999)
SPSS	Quantitative analysis software used for the multiple regression analysis for the survey study.
URIs	University, Research, and Institutes
VAL IT	Value from IT investments

1 CHAPTER ONE: INTRODUCTION

1.1 CHAPTER OVERVIEW

This chapter provides an introduction to this thesis, presenting the motivation and the research process involved in the study. A summarised literature review is provided that gives a brief definition of BIM within the context of the study, and leads to the theoretical point of departure for the research. These theoretical discussions are categorised into two sections, namely BIM and theories relating to Business Value Creation, and SME architectural firms and theories of Intellectual Capitals. Following this, the aims and objectives are outlined, together with an overview of the research design and the scope and boundaries of the study. The chapter is concluded with a description of the thesis structure.

1.2 BACKGROUND OF THE STUDY

The Architecture, Engineering and Construction (AEC) industry is facing a paradigm shift with the use of Building Information Modelling (BIM) and Integrated Design and Delivery Solutions (IDDS) (Owen et al, 2009). This shift can be associated with increased productivity, efficiency, value, quality and sustainability, and with the reduction of lifecycle costs (Arayici et al, 2011a). However, these gains need a corresponding shift in focus and processes, which is more than just a change in the design delivery process or in the tools used. Instead, it requires a social, technical, cultural, and organisational change as well and a fundamental shift in business culture. Although different experiences have brought about diverse definitions of the term BIM, in this context, it is defined as a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life cycle (Succar, 2009). Based on this definition, the changes catalysed by BIM have implications for business processes and practices in the industry. Nevertheless, while most developed countries have moved to adopt this shift and affirmed a substantial improvement in their AEC industries, little or no information of a shift is evident in terms of the emerging markets (Abubakar, 2012).

This study was motivated by research conducted by Kori & Kiviniemi (2015) on the adoption of the BIM in the Nigerian AEC industry; it generated interesting data that has informed this study. In particular, their research involved context framing, and data collection with a paradigm for interpretation. It also involved exploring the experience of the emerging markets in the BIM adoption process. Furthermore, their research suggests that BIM has the potential to transform the AEC industry in the emerging markets, and promises radically improved and efficient design and delivery processes; however, just as it comes with a price in terms of the opportunities available, it as well brought about constraints in the business settings that force practitioners to alter how they design and deliver buildings. To assess their BIM maturity, the study classified architectural firms in Nigeria into large, medium and small-sized firms, and the conclusion was that the larger sized firms were found to be less challenged when incorporating BIM. However, the issues in Small and Medium-sized Enterprises (SME architectural firms) were relatively major as there was a lack of understanding of the process itself and the policies involved. The SME architectural firms involved inclined to regard the whole shift as just a technological stream, and disregarded the accompanying potential of business value creation.

However, it is well acknowledged that these SME architectural firms provide a rich source of knowledge, innovation, and generate value-creating qualities for the economy (Lu & Sexton, 2009; Rispoli & Leung, 2011). This is particularly true in the AEC industry where even the largest companies rely largely on supply chains comprised of countless small businesses (Lu & Sexton, 2009) . Thus, there is potential for these SME architectural firms to increase the productivity of larger industry through the use of BIM; however, the lack of business value creation renders this potential under-exploited. Nevertheless, studies affirm that the culture of SME architectural firms represent a unique system that will adopt and adapt to BIM technology and culture in a different manner than larger practices (Arayici et al, 2011b). A SME architectural firm cannot immediately absorb the initial costs associated with a shift to BIM, whereas larger firms can afford to shift slowly, several people at a time, as they absorb both the non-billable time of employees in training into longer cycles on initial BIM projects (Lu & Korman, 2010). In comparison, SME architectural firms would be forced to develop plans to distribute these costs as shifting to BIM will most likely be an 'all or nothing scenario' and allow employees much less time in training before they are expected to produce billable hours (Poirier et al, 2015). Nevertheless, small firms have unique attributes that can be leveraged for successful BIM adoption in that they are nimble and more cohesive;

furthermore, they have the potential to shift modes of operation easier and with less turbulence.

Intellectual Capital (IC) is one of the promising resources for innovation management that perhaps can address these issues. Stewart (1997) stated '*Information and knowledge are the thermonuclear competitive weapons of our time. Success goes to those who manage their intellectual capital wisely'* (p. 68). Edvinsson & Malone (1997) have defined '*intellectual capital as the possession of the knowledge, applied experience, organizational technology, customer relationships and professional skills that provide a competitive advantage in the marketplace'* (p. 40). Hence, identification and management of IC development can be positioned to become an integral pillars that SME architectural firms can rely upon to create BIM Business Value. The specific experiences of SME architectural firms and their unique attributes in BIM adoption strongly suggest an exploration of this development. This is because, even if the individual ability of an SME architectural firm to mobilise resources for effective BIM implementation is comparatively small, their strategic decisions regarding the orientation towards a higher level of intensity in IC developments is more under their control (Kim & Kumar, 2009), and can be a major catalyst for any BIM Business Value Creation (BBVC).

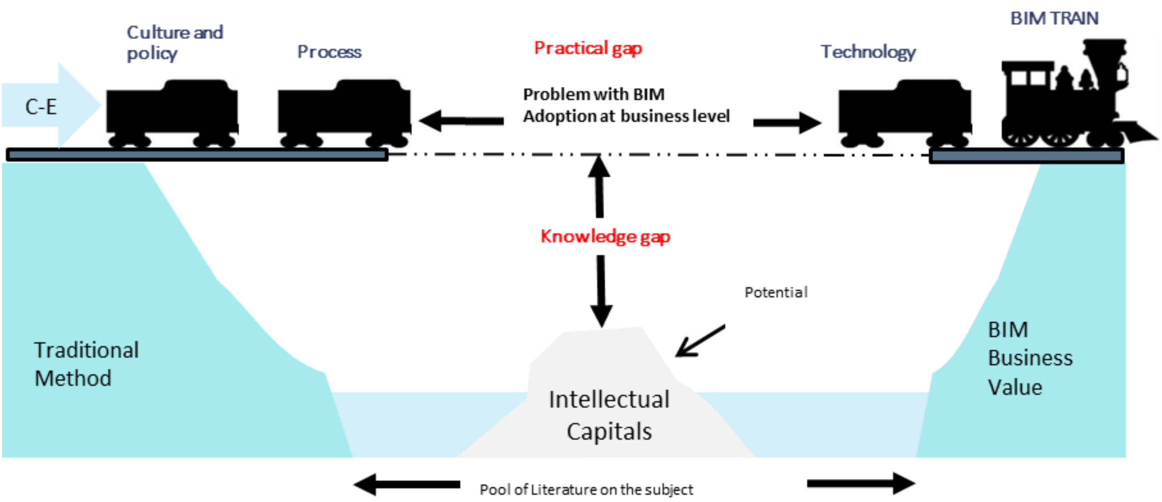

Figure 1: Research problem showing the practical and knowledge gap addressed by the study

Lu & Sexton (2009) in *Innovation in Small Professional Firms in the Built Environment* developed a framework to this effect on Intellectual Capital Compositions specifically for professional SME architectural firms in the built environment and thus is used to guide this study. Based on the framework, this study positioned its proposition that the BIM adoption process is approached as a knowledge-based innovation, which occurs with the development of four IC elements, Human Capital (HC), Relationship Capital (RC) and Structure Capital (SC) through Knowledge Capital (KC), to achieve BIM Business Value Creation (BBVC). Despite the potentials of this IC elements and their development, there is lack of knowledge on their identification and managements in the business environment of the SME architectural firms as well as protocols of deploying them to achieving BBVC. In light of that, this study investigates the theoretical link between the development of these four IC elements and BBVC in SME architectural firms in the emerging markets. The aim of the study is to use the framework of this theoretical link to develop a viable business model for the management and evaluation of the IC development toward BBVC for the SME architectural firms as shown in Figure 1. The study uses the case on the Nigeria AEC industry for the investigation.

1.3 THE RESEARCH PROCESS

The study adopts the research framework known as the CIFE HORSESHOE (Mourgues, 2008), which was developed by the Centre for Integrated Facility Engineering at Stanford University, to frame the research process. The CIFE "horseshoe" research method defines a structured framework to plan and manage theoretical research in the built environment and related fields using a scientific method and the development of new engineering projects and methods (Kunz, 2010).

The framework is comprised of seven integral parts, shown in Figure 2, and the observed problem is a lack of BIM Business Value Creation in SME architectural firms in emerging markets. Whilst the study explores the potential for IC development in SME architectural firms, the research question is based on an investigation of the relationship between this IC development and the BBVC. Figure 2 illustrates the research process of this study, demonstrating the interrelationship between the various methods involved in the research task, the validation criteria, the intellectual contribution of the research, and the practical impact of the study based on the CIFE HORSESHOE research process.

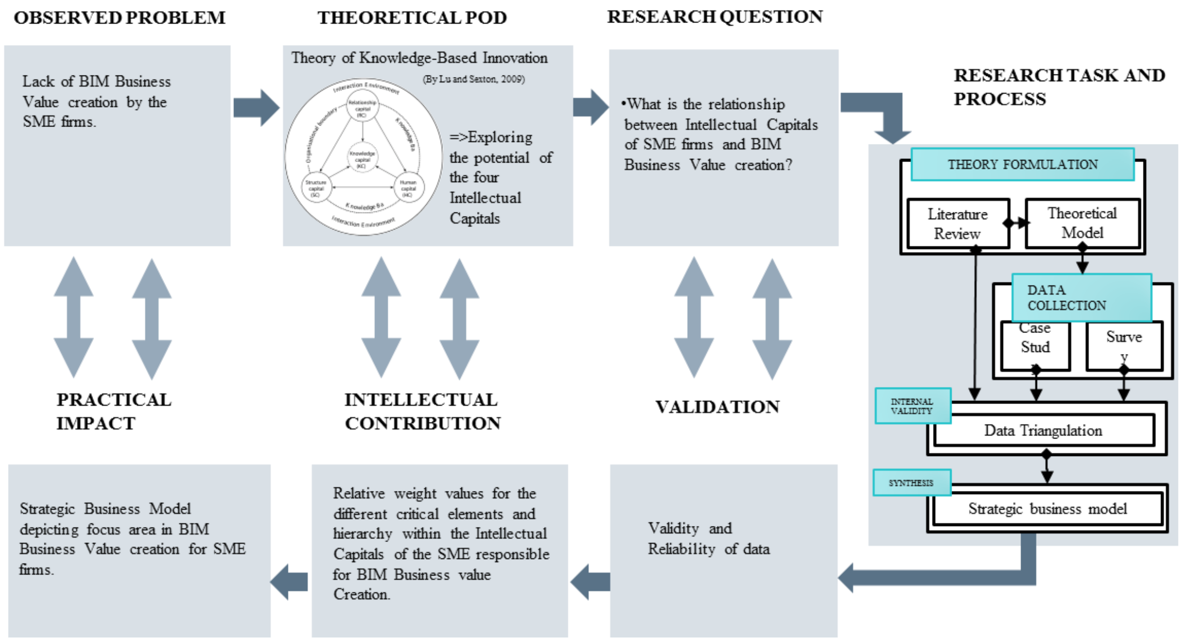

Figure 2: CIFE HORSESHOE Research Framework

1.4 AIM AND OBJECTIVES OF THE RESEARCH

The aim of the research is to develop a viable business model for the management and evaluation of Intellectual Capital (IC) development in SME architectural firms and their impact on BIM Business Value Creation (BBVC) (A case of Nigeria AEC industry).

Objective 1: To identify the various elements that form the development of the IC of SME architectural firms and their effect on BBVC.

Objective 2: To examine the process of Intellectual Capital development by SME architectural firms with BIM capabilities through BBVC.

Objective 3: To identify the extent of the influence of the various elements and hierarchy of the Intellectual Capitals on BBVC.

Objective 4: To develop a Strategic Business Model (SBM) for the effective and efficient deployment of IC for BBVC in SME architectural firms in Nigeria.

Objective 5: To validate the developed SBM based on its implementability, usefulness and generality.

1.5 RESEARCH QUESTIONS

The primary research question is identified as follows:

- What is the relationship between the development of the Intellectual Capital of SME architectural firms and BBVC?

Following this, the secondary research question is determined as:

- How do BIM adopters in SME architectural firms differ from non-adopters in the ways and manner they capture, develop and integrate their Intellectual Capitals?

1.6 THE RESEARCH DESIGN

The study design is based on a pragmatic research philosophy, as defined by (Andrew et al, 2011), and involves a mixed method of both quantitative and qualitative research. A rationale is required for mixing the methods and integrating data at different stages of the inquiry to achieve the aim; this is explained by the fact that the study involves three stages, which are empirical enquiry, analysis and synthesis.

1. *Empirical Enquiry*

   The empirical enquiry comprises theory formulation and fieldwork data collection. The theory formulation proposes an evaluation framework using a systematic review of literature on the four IC elements. The evaluation framework constitutes a set of independent variables comprising thirteen components, which are categorised under the four elements. Each component is defined by a set of indicators, and the proposition developed explores the relationship between these indicators and the components of the IC, and a dependent variable of the BBVC.

   i) The evaluation framework is used to collect data from the fieldwork. It involves a questionnaire survey, and case study interviews from a sample of SME architectural firms in Nigeria. The survey involves administering questionnaires, to firms in Nigeria and, in the same period, case study interviews are also conducted.

2. *Analysis*

   The analysis comprises two methods;

i) The survey data enables the evaluation of the framework using multiple regression analysis. Each component and its sets of indicators represent an independent model of regression in the analysis. The outcome provides statistical evidence of the relationship between the two main variables. Also, it provides the Relative Weighting Value (RWV) for each indicator on the components and their effects on the BBVC.

ii) The case study analysis is used to triangulate the data from the survey results and to provide the RWV for the components and four IC elements. The case study involves six SME architectural firms that have relatively high BIM capabilities; these are drawn from the survey sample during the administration of the questionnaire. The case study analysis is carried out using two approaches: firstly, through an exploratory study using semi-structured interviews. This is based on themes from the 13 intellectual capital components and helps to identify the different indicators employed by firms during the BBVC. Secondly, the Eigenvector method is applied to analyse a pairwise comparison judgement where each of the components discussed in the interviews are compared and their relative importance weighted. The outcome helps to establish reliability and validity within the survey data as well as provide the RWV of both the 13 components and four aspects of the ICs.

3. *Synthesis and Validation*

i) The synthesis of the Strategic Business Model (SBM) uses the Analytical Hierarchy Process (AHP) concept. The SBM depicts the prioritisation of the IC elements based on the following four levels; Indicator, Component, Capitals and Organisation Goals. The SBM enables practitioners with limited resources to manage, prioritise and optimise their IC through the identification and evaluation of a focused area of development.

ii) The SBM is further validated in practice through a focus group with industry experts; this is based on three criteria, which are, implementability, usefulness and generality. The feedback is used to calibrate the model and describe its practical implications. This involves the validation of the model within the practice where the study is conducted. To achieve all the set criteria of the model validation, participants are chosen from a heterogeneous background. They involve policy makers, heads of firms at different levels of BIM adoption, and clients. The outcome of this focus group study is used to document the practical implications of the model, hence its practical validation. The outcome of this stage forms the attainment of all research objectives.

1.7 SCOPE AND BOUNDARY OF STUDY

The scope of this study relates only to small and medium architectural firms, which are referred to as SME architectural firms. With regard to BIM coverage, the study just relates to the business aspect of the BIM adoption process, which is termed BIM Business Value Creation (BBVC). In the context of this study, the term 'SME architectural firms' can be defined as any firm whose employees number fifty at most (Oluwatayo, 2009; Kori, 2013). With regard to the context, the study primarily focuses on Nigeria; however this is narrowed down to some specific regional boundaries within the country. This is because the study deals with BIM technology adoption, which attracts firms whose practice involves ICT activity; furthermore, a previous study by Kori (2013) has shown that the use of ICT is apparently limited to specific areas of the country. Hence, the study chooses nine cities from which to collect data for the fieldwork study, which are; Abuja, Lagos, Kaduna, Kano, Port-Harcourt, Maiduguri, Jos, Bauchi and Ibadan. These cities comprise almost 70% of the registered architectural firms in the country (Kori & Kiviniemi, 2015) .

With regard to unit of study, the study limits its subject to only architectural firms and not all types of architectural practice. This is important to state because the terms 'practice' and 'firm' have been used interchangeably in the literature; however, according to Oluwatayo (2009) the term 'practice' implies the application of an expert body of knowledge to certain social needs, or its occasional use for business. Whereas, according to the American Heritage Dictionary (Dictionary, 2011) , the term 'firm' is an institute where the business of professional personnel is practised. Therefore, since Building Information Modelling is a tool for collaboration, there is a need to specify the firm where the profession of architecture is practised, rather than the practice of the professional; thus, for accuracy the term 'firm' is used for this study. It is also worthwhile clarifying that, although the study aims to use only firms headed by registered architects, a few firms that were not listed in the register (ARCON, 2014) were included after it was realised that registered architects lead them.

Finally, this study was carried out at the level of the firm rather than the individual, in order to gather details of firms' operations.

1.8 THESIS STRUCTURE AND ORGANISATION

This thesis is organised in accordance with the research design of the study. The next part of this chapter elaborates on the background literature review provided earlier, and leads to the theoretical point of departure for the study. The next chapter (Chapter Two) explains in detail the research strategy and the methods employed to achieve the research design. Chapters Three to Five present the findings in relation to the four objectives of the study. Chapter Three presents the research framework in which the evaluation framework was formulated. Chapter Four presents the evaluation of the framework through the analysis of the survey data collected from the fieldwork; the chapter also provides a multiple regression analysis. The findings in Chapters Three and Four relate to the first objective of the study. Chapter Five presents the case study analysis including the analysis of the six firms with relatively high BIM capabilities. This analysis relates to objective one of the study and the findings demonstrate the attainment of objectives two and three. Chapter Six describes the attainment of objective four of the study, where the findings from Chapters Three to Five are used to develop a strategic business model. Through a discussion of the focus group study findings, the validation of the model is also presented in this chapter. Figure 3 explains the interrelationship between the research objectives, the chapter structures and the research design of the study.

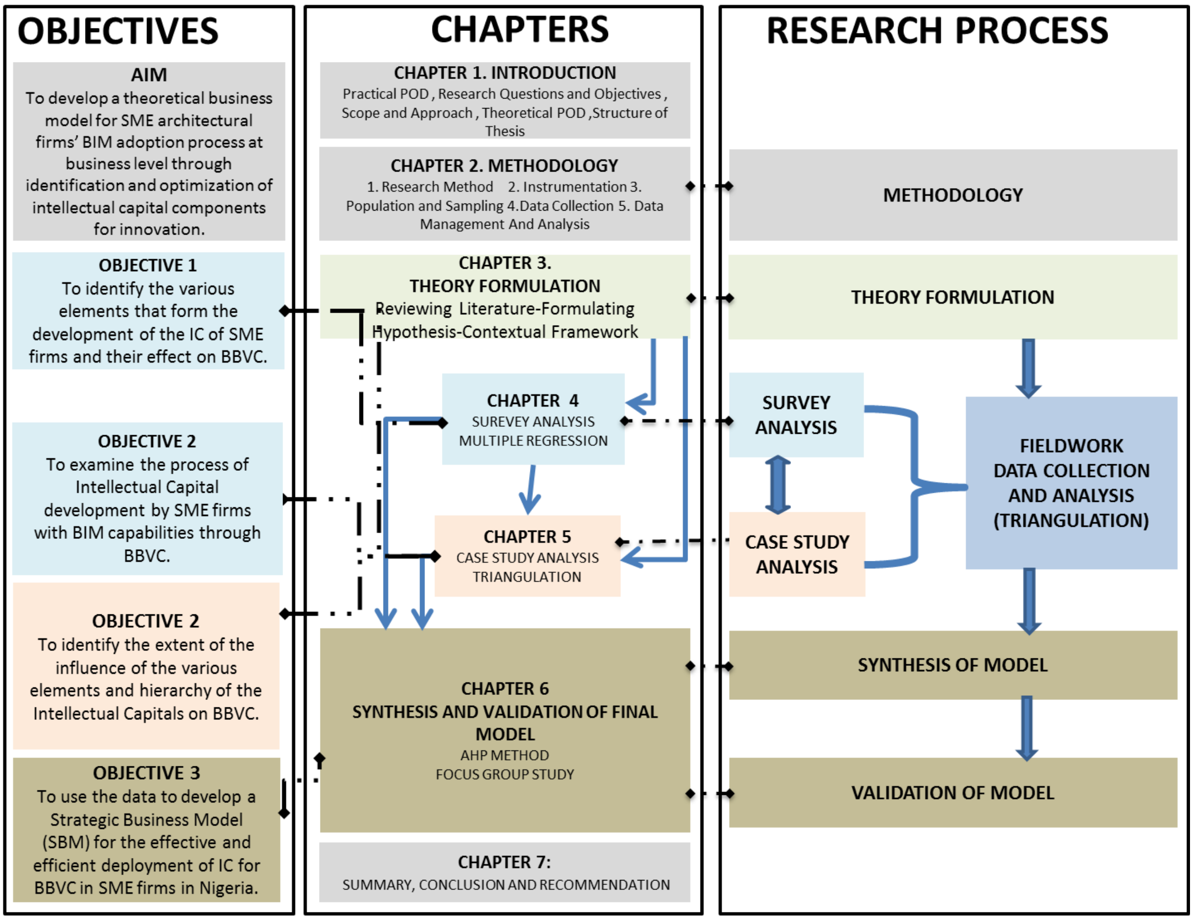

Figure 3: Thesis structure and organisation

1.9 THEORETICAL POINTS OF DEPARTURE

1.9.1 DEFINING BIM IN THE CONTEXT OF THIS STUDY

Despite the emerging interest of both practitioners and academics in the AEC industry, there is no agreed definition of the term 'BIM'. Furthermore, there is no consensus on the outcomes that the stakeholders (contractors, architects, engineers, and owners) experience from its application to a construction project (Barlish & Sullivan, 2012). The lack of agreement or consensus can be particularly true when viewed from a business value perspective. For example, some view BIM as a process of creating and using digital models for the design, construction and operations of projects (McGraw-Hill, 2009), while some see it as a process of managing building information (Jongeling, 2008), and others view it as an entirely new approach for managing processes, policies, contracts and relationships (Aranda-Mena et al, 2009) or for managing the entire life cycle of a building (Succar, 2009). However, there is still a convergence in most of these definitions; for instance, Succar (2009) explicitly defined it as, "*a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the buildings life cycle*" (p.3). Similarly, a more holistic definition is used by the National BIM Standard (NBIMS) Project Committee of the BuildingSMARTalliance (2015) BuildingSMARTalliance (2015) '*A Building Information Model (BIM) is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward'* (P.1). The BIM is a shared digital representation founded on open standards for interoperability.

1.9.2 BIM INNOVATION AND BUSINESS MODEL

The effective use of BIM forces small firms to adopt new business models and methods of design and production (Eastman et al, 2011); however, it is difficult to provide a generic or typical business model of BIM adoption for the AEC industry. According to Aranda-Mena et al (2009), " *For a business case to be reliable, it must be developed to achieve specific objectives or outcomes taking into consideration the clearer the objectives are defined, and the specific circumstances of the company analysed, the better the business case will be."* (P.431) As a result, the need for SME architectural firms to shift to BIM cannot be overemphasised. However, the fact that they may be unprepared for the accompanying shift in business models and processes creates a problem for the industry. BIM implementation can increase the quality of design services, but it means changing the methods of design delivery, and this has a fundamental impact on the design services business model. By far the most important yet least addressed aspect of implementing BIM is the corresponding change in business practices needed to optimise the opportunity afforded by BIM (Smith & Tardif, 2009). Thus, the shift to BIM requires a fundamental shift in business culture, *"Cultural transformation is a greater challenge to the industry than any technological transformation resulting from BIM."(Smith & Tardif, 2009)* in (P.35).

1.9.3 THE BIM ADOPTION PROCESS AND BUSINESS VALUE CREATION.

Building on the definition by Succar (2009), the concept of BIM is widely seen as continuing in coverage and connotation. Hence, Succar (2009) highlighted the importance of assisting the AEC industry in moving toward the systematic adoption of BIM, and identified the importance of determining the domain's knowledge structures, internal dynamics and implementation requirements, as these are key elements involved in any systematic adoption. Vass (2015) suggested that the expectations on digitalisation as a driver for change in the AEC industry date back to the last three decades when object-based parametric modelling and early 3D modelling through computer-aided design (CAD) were introduced. Since then, numerous studies have been conducted that have evaluated the adoption and application areas of BIM with regard to its business value. Until recently, the term ‘BIM Business Value’ was only used in specific BIM reports (McGraw-Hill, 2009); for example, the report by (McGraw-Hill, 2009) launched the term ‘business value of BIM’. Although Vass (2015) suggested that the high expectations associated with BIM implementation have been strongly influenced by AEC industry representatives and software developers, reports such as that by McGraw-Hill have not defined nor explained what the business value of BIM means nor how it can be understood. Despite this, McGraw-Hill’s report has had a significant impact on how the concept of the business value of BIM is used and recognised within the industry and academia.

1.9.4 DEFINING BIM BUSINESS VALUE CREATION (BBVC)

Despite the various approaches and definition of BIM Business Value, this study is constrained by the fact that, in Nigeria which is the context of the study for data collection, the concept of BIM is not well established and adopted. Hence, the need for systematic collection of data to establish BIM Business Value Creation level becomes essential. Thus, in order to understand the study has examined the literature of Information Technology (IT) business value where the concept is rather more established (Vass, 2015) and relevant to emerging markets like Nigeria. However, ‘business value’ remains as an informal term that includes all forms of value that determine the strength and well-being of a firm in the long term (Racheva et al, 2009). The study therefore adopts the concept with respect to the capability level of the firm to adopt the BIM technology as the Business Value. This is because, in the literature concerning IT business value, the concept has been defined as a combination of the economic and non-economic impacts of IT on organisational performances (Kohli & Grover, 2008; Schryen, 2013). Similarly, Vass (2014) also described the concept of IT business value as a journey focusing on only the economic effects of IT, such as productivity and returns on sales; however, the non-economic and intangible effects of IT, such as organisational capabilities and strategic position, are also significant. This is evident in the work of Curley (2004) who questioned how it is possible to quantify business value, choose the best IT investments, build an IT capability for delivering sustainable competitive advantage, and manage for optimal IT business value. Furthermore, Vass (2015) suggested factors that need to be taken into consideration when examining IT Business Value in organisations, and this includes organisational; strategy, process, structures, skills, knowledge, capabilities, change, power structures and politics, and culture. However, despite the substantial volume of IT literature on the concept of business value, there is still no precise and particular definition (Schryen, 2013; Vass, 2015). Nevertheless, in trying to justify the continued ambiguity of the concept in IT literature, Racheva et al (2009) suggested that it cannot be defined independently of other activities nor as the vision of the business.

Therefore, the concept of a business model for BIM adoption is still an ambiguous concept. For example, while Vass (2015) considered BBVC as the degree to which a firm perceives the economic value of BIM, Succar (2009) and McGraw-Hill (2009) viewed it as the capability and maturity of a firm to realise the benefits that BIM brings to the business environment. Becerik-Gerber & Rice (2010) focused on the tangible benefits and costs associated with BIM use at a project level, whilst Vass (2014) concentrated on how BIM improves productivity, efficiency, quality and project safety, as well as competitive advantage. Nevertheless, despite the ambiguous use of the term, there is a convergence within the literature in the fact that BBVC is a measure of the capability of the firm to reap the business benefits accorded by BIM technology. This view is also widely accepted in the domain of IT business value (Curley, 2004). Furthermore, Succar (2009) argued that, since BIM entails an expanding collection of concepts and tools which are attributed with transformative capabilities for the AEC industry, a discussion on BIM Business value also needs to accommodate an increase in its software capabilities, its infinitely various deliverables, and its competing standards. Although McGraw-Hill (2009) described BIM as the process of creating and using digital models for the design, construction and operation of projects, Harty (2012) highlighted that the real business value of BIM lies in the collaboration level it brings to an organisation.

1.9.5 THE NIGERIAN AEC INDUSTRY AND THE MEASURE OF BBVC

Although not many studies have been explicitly conducted on BIM adoption because BIM is commonly referred to as ICT in construction within the Nigerian AEC industry, there are numerous studies on the adoption of ICT that can be used as a reference point for this study (Oyediran & Odusami, 2005; Oladapo, 2006; Oladapo, 2007; Ogwueleka, 2015). With regard to BIM adoption, studies by Kori & Kiviniemi (2015), Abubakar et al (2014), Ibrahim & Abullahi (2016), Hammad et al (2012), Ogwueleka (2015) are among the few pieces of research that explicitly relate to BIM capability and maturity.

Using four readiness components (management, people, process and technology), Abubakar (2012) found that Nigerian Building Design firms were not fully ready to adopt BIM as at the time of his study . The study reported various readiness levels across the different categories of firm, with some firms ready in some components, but needing critical attention in others in order to attain full readiness. Similarly, although the Nigerian Public Sector has demonstrated a certain level of preparedness for BIM adoption in some readiness components; however, the Nigerian public sector is also not fully ready for BIM implementation. Ibrahim & Abullahi (2016) assessed the readiness of the Nigerian public sector to implement BIM in its project delivery process. Whilst the results of their study indicated that the federal ministries have achieved management, and process and technology readiness, they still need to invest more effort into improving people's readiness.

Another study by Abubakar et al (2014) at the larger industry level suggested that factors such as: the availability of trained professionals to handle BIM tools'; 'software availability and affordability'; 'enabling demands'; 'client demands'; market demands; competitive advantage; and a growing awareness of BIM were identified as the major drivers influencing the industry's preparedness. Indeed, based on Succar (2009) measurement, the industry was assessed to be at BIM Capability Level 1. However, the Kori & Kiviniemi (2015) study is relevant to this research and the source of its motivation in that it explicitly developed a capability measure by studying the firms in Nigeria. According to the study, SME architectural firms are lagging behind larger firms, which is a similar finding to previous studies on SME firms in other countries. The study stated that there are a significant percentage of firms that have not even started using BIM. The conclusion of the study, which relates largely to this study are outlined below:

1) The majority of SME architectural firms are in the object-based modelling stage
2) Only a few firms operate in the model-based collaboration stage.
3) A significant percentage of the SME architectural firms are at the pre-BIM stage.
4) SME architectural firms in the Nigerian AEC industry are still using traditional methods and adopting computers only for office related work rather than design work.
5) SME architectural firms use digital tools mainly for sketching and modelling, and usually only printed copies are shared for visualisation and presentation; this makes the use of BIM almost obsolete. BIM is generally regarded as a technology stream without much consideration to the business process, and its implementation lacks any performance and improvement strategy; there is also a similar lack of leadership and motivation in this area. Moreover, less regard is given to the product and service potential of the tools in producing a more comprehensive, information-rich model. There is a lack of any policies, rules, guidelines or standards in the use of the digital tools as the industry perception of BIM is of a technology, and less to no focus is given to its contractual and regulatory aspects.
6) Among the few SME architectural firms that demonstrate a somewhat model-based collaboration, such collaboration is still limited to medium size firms and tools are mainly used for modelling and visualisation while printed copies remain the main media for interdisciplinary collaboration. Apparently, in this category, BIM is still largely regarded as a technology stream. Although there is some knowledge about the process, this is reluctantly adhered to, with less motivation and a lack of leadership.

The above conclusions, coupled with the discussions with SME architectural firms, have helped in providing a point of departure for shaping the BIM Maturity and Capability Model and the BIM Business Value Creation (BBVC) to fit the context of this study which is further explained in detail in Chapter Three of this thesis.

1.9.6 BIM ASSESSEMENT MODELS

A BIM assessment model is also crucial in that provides it a point of departure for this study through a means of BIM performance measurement in organisations (Succar et al, 2012). Although the intended goal of this model is in its practice application, it can also provide an insight into theoretical investigations by identifying the level of BIM adoption in firms. Succar et al (2012) proposed three sets of BIM competencies and requirements, and argued that BIM competencies are a direct reflection of BIM requirements and deliverables. Indeed, (Succar et al, 2012) listed the elements under each set and grouped them under Technology, Process and Policy, as follows:

- **Technology** sets in software, hardware and networks; for example, the availability of a BIM tool allows the migration from drafting-based to object-based workflow, which is a requirement of BIM Stage 1
- **Process** sets in leadership, infrastructure, human resources, and products/services; for example, collaboration processes and database-sharing skills are necessary to allow model-based collaboration, which is a requirement for BIM Stage 2.
- **Policy** sets in contracts, regulations, and research/education; for example, alliance-based or risk sharing contractual agreements are pre-requisites to network-based integration, which are features of BIM Stage 3.

These elements provide a useful insight when developing survey specific questions, in identifying the levels of readiness and adoption of BIM technology in Nigerian firms.

1.9.7 THEORIES OF INNOVATION AND BIM ADOPTION PROCESS

The SME architectural firms have proven to be subjective in adopting technology innovations. Small construction firms absorb and use technology, which can contribute to the business in a quick, tangible fashion, and which can be dovetailed into organisational capabilities they already possess, or which can be readily acquired or "borrowed" through their supplier and business networks. Any technology which is too far removed from this "comfort zone", and which requires too much investment and contains too much risk, tends to be intuitively and swiftly shifted out (Sexton and Barrett, 2004). Although BIM is not far from such a comfort zone, it is still outside of it; BIM innovations will have to redefine the firms in other to optimise its afforded opportunity. Investigations in how such innovations are deployed and adapted were considered in guiding this research.

Crucial to examining the prospects of BIM adoption in a given context, especially among the SME architectural firms, is also establishing the level of how similar technologies are adopted in that context and identifying the specific factors that affect it. According to Rogers (2003) the level of innovation adoption can be determined or gauged by several factors, but perhaps most important among them are subjective perceptions derived from personal experiences. These perceptions and how they are shared across networks are shown to drive the innovation diffusion process. BIM is a complex tool that requires fundamental changes in existing working and collaboration methods. These qualities are likely to produce subjective perceptions and personal experiences that seriously impact the diffusion process. Rogers (2003) continues to define five stages involved in the adoption process: knowledge, persuasion, decision, implementation, and confirmation. These stages provide a basis to formulate an evaluation framework for investigating adoption process of BIM in the SME firms. Theories of Diffusion of Innovation by Roger (2003) was, therefore considered crucial to this research, which is determining emerging business models in the wake of ICT adoption in the Nigerian context.

Technology usage is a reflection of acceptance by users (Venkatesh 1999). Parasuraman (2000) claimed that users' positive attitude and belief in technology are related to user tendencies in accepting technology. Similarly, while BIM usage has many benefits for information management in the AEC, the factors causing BIM user resistance are somewhat not necessary technological but environmental factors and organisation-related factors of the users.

Technology Acceptance Model (TAM) is also an important concept considered by this study, which is introduced by Davis (1989), is an adaptation of the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB) tailored explicitly for modelling user behaviour in acceptance of the technology. The goal of this theory is to explain the determinants of technology acceptance that is capable of explaining user behaviour across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified (Van Slyke and Craig, 2008). In this model, perceived usefulness and perceived ease of use are of primary relevance for IS acceptance behaviour. Davis (1989) proposes that there may be external variables indirectly affecting attitude toward use, which ultimately leads to actual system use by influencing perceived usefulness and perceived ease of use. Several later studies affirm that by developing an extended version of Davis's TAM by adding the external variables in it with the aim of exploring the effects of external factors on users' attitude, behavioural intention and actual use of technology.

1.9.8 INTELLECTUAL CAPITALS AND SME ARCHITECTURAL FIRMS

According to Stewart (1997) , intellectual capital is *'packaged useful knowledge'* (p. 67). More explicitly, he writes: '*Intelligence becomes an asset when some useful order is created out of free floating brainpower-that is, when it is given coherent form; when it is captured in a way that allows it to be described, shared and exploited, and when it can be deployed to do something that could not be done if it remained scattered around like so many coins in a gutter.... The overall theory is that knowledge assets, like money or equipment, exist and are worth cultivating only in the context of strategy* ' (p. 70).

In another context, Sexton & Barrett (2004) suggested that SME architectural firms have proven to be subjective in adopting technology innovations in that, they stated that '*Small construction firms absorb and use technology which can contribute to the business in a quick, tangible fashion, and which can be dovetailed into organisational capabilities they already possess, or which can be readily acquired or "borrowed" through their supplier and business networks. Any technology which is too far removed from this "comfort zone", and which requires too much investment and contains too much risk, tends to be intuitively and swiftly shifted out' (*p. 651).

While, Professor Trevor Mole in the *Forward* to the book, *Innovation in Small Professional Practices in the Built Environment* by Lu & Sexton (2009), outlines the interdependence of the evaluation framework for evaluating innovation in small professional practices with the Business Value Creation which relates to this study. He stated that*, "Creating, maintaining and developing small professional practices are based on the notion that the business will have knowledge and expertise worthy of being sold in the marketplace. In other words, it has knowledge capital that is valuable, but how is this capital captured, integrated, managed, exploited and developed in a business made up of highly skilled individuals and teams? To answer this question, it is necessary to understand the nature of knowledge, its dimensions and variety which are critical in the creation of knowledge capital."*

Putting these assertions and points together, Intellectual Capital is indeed a promising resource that can be integral in helping SME architectural firms in BIM Business Value Creation. Because, the strategic decision of each SME architectural firms to develop and orient its IC development is within its power and may not require the complexity of financial and resource involvement of the BIM shift.

Lu & Sexton (2009), who are the author of the book (*Innovation in Small Professional Practices in the Built Environment),* outlined a framework unique to SME architectural professional service firms that is relevant to this study called the Knowledge-based innovation. This framework is based on the notion of the Intellectual Capital development which is defined as the effective generation and implementation of a new idea, which enhances the overall organisational performance, through appropriate exploitative and explorative Knowledge Capital that develops and integrates Relationship Capital, Structure Capital, and Human Capital. This is based on their analysis of the professional service SME architectural firms based on four principal characteristics from an extensive literature review which is relevant to firms in the AEC industry that:

1. Professional services are knowledge–intensive in nature,
2. Professional services are delivered by professional/knowledge workers,
3. Professional services are nonetheless co-produced between the knowledge worker and the client,
4. The majority of construction professional services are provided by small firms.

Based on their framework, this study positioned a proposition that regards BIM shift as a knowledge-based innovation, which occurs with the development and integration of Human Capital, Structure Capital, and Relationship Capital. These capitals are crucial for the business processes and success of SME architectural firms, and they also affect the BIM adoption process. Hence, it is essential to investigate and understand the nature of these capitals, including their dimensions, and variety. However, Lu and Sexton's definitions of these capitals help to develop this investigation. Thus, the following sections, a narrow definition of each capital in relation to this study is presented, based on Lu and Sexton's original definitions.

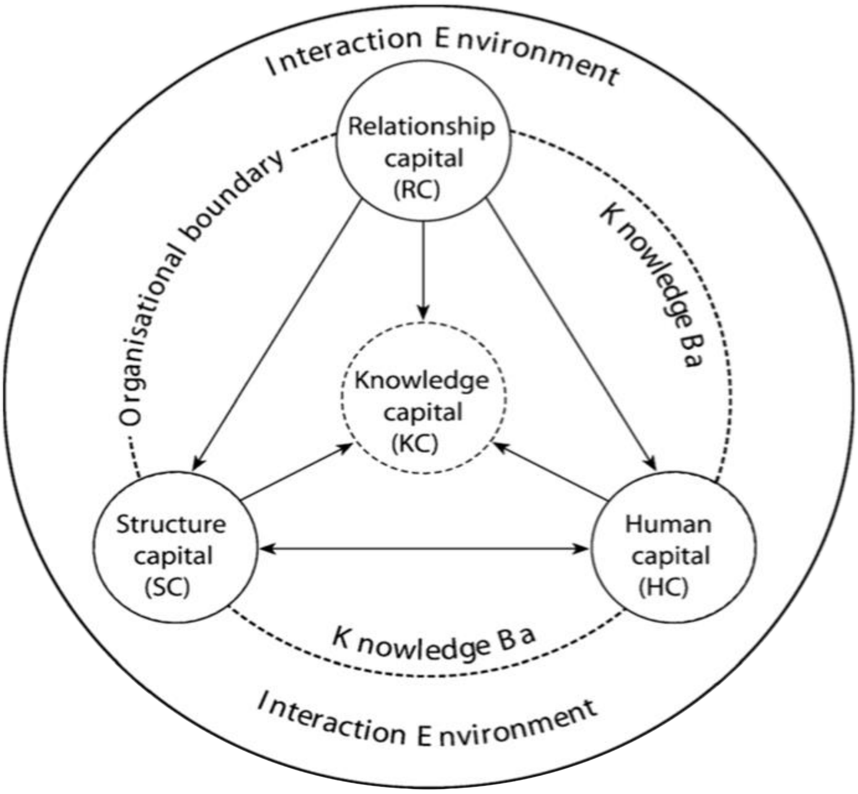

Figure 4: A framework for Innovation in small professional service firms by Lu & Sexton (2009)

1.9.8.1 Relationship Capital (RC)

In terms of the BIM adoption process, Lu & Sexton (2009) presented two elements in their framework that could be termed as BIM Relationship Capitals, and these are the interaction environment and their Relationship Capital. Their definition of the interaction environment emphasised the business environment where interactions take place between the organisational team members and the competitive environment. Meanwhile, in the definition of Relationship Capital, emphasis was given to the interactions between the individual, organisation, and external supply chain partners, which includes the reputation or image within the organisational hierarchy. The interaction environment and the organisational hierarchy are separated by a permeable organisational boundary; however, the Relationship Capital represents the means to leverage Human Capital (Lu & Sexton, 2009). However, a BIM-enabled process already recognises and involves the interaction environment as an integral stakeholder and directly leverages Human Capital. The interaction environment in the BIM adoption process includes the IT vendors, government organisations, and academic institutions, among others. Meanwhile, the BIM Relationship Capital can be defined as the network capital of the firm that occurs in the interaction between, the internal, external and environmental relationships. The internal relationships includes those between workers, managers, and the internal hierarchy, whilst the external relationships are those between workers and clients, consultants, contractors, and any other entity external to the company.

1.9.8.2 Human Capital (HC)

Lu & Sexton (2009) definition of Human Capital emphasised the capability and motivations of individuals within small construction professional firms, the client systems, and the external supply chain partners, in performing productive and professional work in a wide variety of situations. However, BIM Human Capital could also focus on how the firm cultivates and deals with individual employees including managers' capabilities and motivations within and outside the firm.

1.9.8.3 Structure Capital (SC)

Lu & Sexton (2009) defined Structure Capital as the resources of the firm that comprise systems and processes; this includes company strategies, machines, tools, work routines and administrative systems for the codifying and storing knowledge from individual, organisational and external supply chain partners. However, BIM Structure Capital can also be defined as the dimensional and non-dimensional resources of the firm where Human and Relationship Capital are used to capture, integrate, manage, exploit and develop the BIM-enabled process in the firm.

1.9.8.4 Knowledge Capital (KC)

The Knowledge Capital of a firm is defined as the dynamic synthesis of both the 'context' and 'process' of knowledge creation and conversion in the business environment, and the 'content' of the Relationship, Structure, and Human Capitals Lu & Sexton (2009). In relation to BIM, Knowledge Capital can be defined as the process and system channels of exploration, transformation and exploitation in order to integrate and utilise BIM in a small firm setting. Therefore, small and medium-sized firms depend on a business format comprised of the knowledge-based resources of individuals, networks, systems and process. However, a question arises as to how this capital can be captured, integrated, managed, exploited and developed during the BIM adoption process. This question informs the first objective of this study, which is to identify the nature of these capitals, and their dimensions and variety, which are critical in the creation of a successful BIM adoption process. The investigation into the theoretical link between these four elements of IC and BIM Business Value Creation (BBVC) forms the theoretical point of departure for this study.

Knowledge Capital unlike the other three capitals above serves as the permeable channel through which all the three HC, RC and the SC components realised their potential to create BIM Business Value.

1.10 CHAPTER SUMMARY

The chapter introduces the study as a framework for exploring the cultural impact of the BIM adoption process in SME architectural firms. Although BIM has strengthened its position in bringing efficiency in the AEC industry, the shift to its adoption and implementation in the emerging markets have caused distortion in both the business processes and environments for Small and Medium Enterprise (SME architectural) firms. This is due to their limited resources to absorb the initial costs associated with such a shift. The starting point for the study was to explore the potential to develop the Intellectual Capital (IC) of SME architectural firms. This is because, even if their ability to mobilise resources is small, the strategic decisions regarding their orientation towards a higher level of intensity in IC elements are still under their control, and can be a major catalyst for BIM success.

As a result, the study established its point of departure based on Lu & Sexton (2009) *Theory of Innovation in Small Professional Firms*. This theory advocates that the BIM adoption process is approached as a knowledge-based innovation which occurs through the development of four IC elements; Human Capital (HC), Relationship Capital (RC), Structure Capital (SC), and Knowledge Capital (KC) to achieve BIM Business Value Creation (BBVC). This study investigates the theoretical link between the development of these four IC elements and BBVC in SME architectural firms in the emerging markets, with a particular focus on Nigeria as a case study. The aim of the research is therefore to use this evaluation framework to develop a viable business model for the management and evaluation of IC in SME architectural firms to gain BBVC.

2 CHAPTER TWO: METHODOLOGY

2.1 CHAPTER OVERVIEW

This chapter discusses the research methodology and process of this study. It articulates the research design and the justifications for the choices of research method and strategy used. The chapter begins with discussion on the Research Strategy adopted by the study where the appropriate research philosophy and methods are presented. This is followed by the discussion on the research design of the study. An evaluation of the credibility of the research design is also presented. Subsequently, the chapter also discusses in detail the two main research methods employed by the study for collecting data from the fieldwork namely; the survey and the case study method. In the end, the chapter summary is presented.

2.2 RESEARCH STRATEGY

The adoption of a research strategy depends on the type of the research operation in question and involves the aim, objectives and the type of outcomes expected from the study. It also addresses the degree of control that can be exercised by the study over the variables and whether the focal point concerns the past or current events (Yin, 1994). This study aimed to develop a viable business model based on empirical data from a social experience of SME architectural firms. Assessing and examining the development of IC in small firms requires a social science approach; however, social science research in the field of AEC is relatively complex compared with management research (Knight & Ruddock, 2009). This is attributed to the fact that many AEC studys are academically trained in professional areas rather than traditional postgraduate research (Knight & Ruddock, 2009). This creates a sort of paradox where, on the one hand, there is much happening in the profession, while, on the other hand, there is no well-established body of work to build from (Harty, 2012). This is particularly true in the case of this study where there is a significant lack of knowledge in the social aspects of BIM technology and also less knowledge on the field in the context of the study of Nigeria, and this provides complexity in the choice of an appropriate research strategy (Harty, 2012). In the following sections, discussion is presented on how this complexity is addressed based on research philosophy and methods deployed in achieving the research aim.

2.2.1 PHILOSOPHY

Positivism and interpretivism are two fundamental approaches in social science research (Bryman, 2015) and they represent two mutually exclusive paradigms concerning the nature and source of knowledge (Andrew et al, 2011). However, in complex situations, such as this study, this clarity can be difficult to isolate. Thus, the quantitative approach, which tends to lead to positivism, needs further insight and an understanding of the various perceptions involved in order to gain a qualified understanding of the issue. The qualitative approach enlists beliefs, opinions and views to gather data, which while being rich in content and scope, is open to a range of interpretations (Fellows & Liu, 2015) .

Nevertheless, in building a case, much empirical evidence comes from obtaining and verifying data (Harty, 2012). Clough & Nutbrown (2012) argued that the adoption of a strategy should show not only the advantage of a method for the given purposes of the study, but also how and why this way of doing it is unavoidable and required by the context and purpose of the particular enquiry. In this regard, Collis & Hussey (2013) suggested that there is an occasional need for studys to modify their philosophical assumptions over time and move to a new position on the continuum; and these modified philosophical assumptions are adapted by pragmatic studys. Onwuegbuzie & Leech (2005) added that, "*Pragmatic studys are more likely to be cognisant of all available research techniques and to elect methods with respect to their value for addressing the underlying research question, rather than with regard to some preconceived bias about which paradigm is a hegemony in social science research."* (p. 385). This situation lends itself better to inter-supportive goals and objectives, particularly through mixing of the two or more research methods to maintain a developmental position.

According to a pragmatic research philosophy, the research question is the most important determinant of the research philosophy just as in the case of this study. Pragmatics can combine both positivist and interpretivist positions within the scope of a single research study and according to the nature of the research question (Dudovskiy, 2016). Pragmatism accepts concepts to be relevant only if they support action, and pragmatics recognise that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture and that there may be multiple realities (Saunders, 2011). Table 1 illustrates the major differences between the research philosophies of interpretivism, positivism and pragmatism.

In light of this, the pragmatism research philosophy is adopted for this study where a mixed method of both quantitative and qualitative research are involved. A rationale for that is used to proposed mixing multiple methods and integrating data at different stages of the inquiry to achieve the aim of this research (Andrew et al, 2011).

This method is chosen because, the context at which the data collection can be made is new with the concept of the BIM adoption process, and hence, the combination of both methods can mitigate against the flaws of either method.

Table 1: Comparing the research philosophies of constructivism, positivism and pragmatism

(Source: Andrew et. al., 2011)

Philosophy	**Interpretivism**	**Positivism**	**Pragmatism**
Type of research	Qualitative	Quantitative	Mixed
Methods	Open-ended questions, emerging approaches, text and/or image data	Closed-ended questions, pre-determined approaches, numeric data	Both, open and closed-ended questions, both, emerging and predetermined approaches, and both, qualitative and quantitative data analysis
Research practices	Positions study within the context Collects participant-generate meanings Focuses on a single concept or phenomenon Brings personal values into the study Studies the context or setting of participants Validates the accuracy of findings Interprets the data Creates an agenda for change or reform Involves study in collaborating with participants	Tests or verifies theories or explanations Identifies variables of interest Relates variables in questions or hypotheses Uses standards of reliability and validity Observes and then measures information numerically Uses unbiased approaches Employs statistical procedures	Collects both, qualitative and quantitative data Develops a rationale for mixing methods Integrates the data at various stages of inquiry Presents visual pictures of the procedures in the study Employs practices of both qualitative and quantitative research

2.2.2 RESEARCH METHODS

Brannen (2005) stated "*The claim that qualitative research uses words while quantitative research uses numbers is overly simplistic. A further claim that qualitative studies focus on meanings while quantitative research is concerned with behaviour is also not fully supported since both may be concerned with people's views and actions. The association of qualitative research with an inductive logic of enquiry and quantitative research with hypothetic-induction can often be reversed in practice; both types of research may employ both forms of logic*" (p.175). A mixed method therefore arguably amounts to pluralism. In this study, this approach is found to be useful because, the concept of BIM is not well established in the context of Nigeria where data collection can be made. Studys demonstrated flaws in the purely inductive and theory-based, independent study's observations (Mingers & Gill, 1997). They also noted similar trends in soft approaches supporting the emergence of these mixed methods, where the use of multiple theoretical models and multiple methodological approaches is both legitimate and desirable if established models and understandings are to be questioned and inherent knowledge extended. Thus, in accepting that studies related to BIM technology is a relatively new academic field and without established practices (Harty, 2012), a fundamental issue arises in establishing a philosophical position. While positivism and quantitative methods have been in the ascendency in some academic fields (Fellows & Liu, 2015), the contrasting philosophy of interpretivism espouses the importance of understanding human behaviour. This provides complementary insights, which can ultimately enrich the understanding of those who work in construction (Harty, 2012). The mixed method in this context comprises of the survey and the case study method which are explained in detail in the later part of this chapter.

2.3 RESEARCH DESIGN

The research design refers to the overall strategy chosen to integrate the different components of the study in a coherent and logical way, thereby ensuring an effective way of addressing a research problem. It constitutes the blueprint for the collection, measurement, and analysis of data (De Vaus & de Vaus, 2001; Trochim, 2006). The study design was based on a pragmatic research philosophy, as defined by Andrew et al (2011) and involved a mixed method of both quantitative and qualitative research. It meant developing a rationale for mixing the methods and integrating data at different stages of the inquiry to achieve the aim. As a result, the study involved three stages, which were as follows;

(i) Empirical enquiry,
(ii) Analysis,
(iii) Synthesis and validation.

The empirical enquiry is conducted in two steps, namely by theory formulation and fieldwork data collection. The theory formulation involved gathering data through a literature review to formulate an evaluation model that became the evaluation framework for the study. This framework guided the design and development of the data collection tools in the fieldwork study, whilst the fieldwork involved a questionnaire survey and a case study interview.

Theory formulation is a step in developing a theory that incorporates all the relevant factors contributing to the research problem (Grant & Osanloo, 2014) . It integrates information from the literature review in a logical manner, hence it is a collection of theories and models that help in conceptualising and postulating an evaluation framework to guide the study. In other words, it explains the research questions and clearly identifies and labels variables (Hussey & Hussey, 1997). For this study, theory formulation was achieved through proposing an evaluation framework using a systematic review of the literature concerning the four elements of IC. The evaluation framework constitutes a set of independent variables comprising thirteen components that were categorised under these four elements; each component was defined by a set of indicators. The proposition is a relationship between these indicators, the components of the IC, and a dependent variable of the BBVC.

The fieldwork comprised two methods of data collection:

1. Questionnaire survey
2. Case study

The questionnaire survey is a pre-formulated written set of questions to which respondents record their answers from closely defined alternatives (Sekaran, 2003). This was the principal method used in gathering data for this study.

In comparison, the case study method was used to achieve two goals; firstly, to complement the data collected from the literature and survey. Since the variables that identified for the evaluation framework development were from literature, it was essential to reinforce them through a case study method. This was achieved through in-depth interviews with firms that have relatively higher BIM capability. The results of the case study analysis were later compared to the results from the questionnaire survey. This approach formed a data triangulation that was used to reinforce the internal reliability and validity of the study. Secondly, to identify the extent to which the different elements of the IC impact on the BBVC. This uses a pairwise comparison studies, carried out with the same firms involved in the interview.

The methods and techniques of the analysis adopted by the study are discussed extensively later in the chapter. The main purpose of this stage was to assess the data collected from the fieldwork in the study.

2.3.1 AN EVALUATION OF THE CREDIBILITY OF THE RESEARCH DESIGN

An evaluation of the credibility of the research design is a step in reinforcing the reliability and validity of the research findings. Whatever research methodology is adopted for the research, reliability and validity are integral to the credibility of the research design (Miles & Huberman, 1994). In this study, triangulation is adopted and ensured in the research design process to evaluate the credibility.

2.3.1.1 Triangulation

Triangulation is a strategy for improving the validity and reliability of the research or evaluation (Apulu, 2012). This study employs sequential type of triangulation which can be achieved through a combination of multiple methods in arriving at a more appropriate point and that the use of this approach strengthens the credibility of the research findings (Golafshani, 2003). Triangulation refers to the use of more than one approach for the investigation of a research question in order to enhance confidence in the ensuing findings (Bryman, 2015). In this study, this is achieved through ensuring that the result of the survey study, which itself is built based on a systematic review of literature, is further combined with evidence from the case study to ensure validity and reliability. According to Webb et al (1966), when a proposition has been confirmed by two or more independent measurement processes, the uncertainty of its interpretation is greatly reduced, suggesting that the most persuasive evidence comes through a triangulation of measurement processes. Thus, the research design in this study, which involved the use of multi method research in which a quantitative and a qualitative research method are combined to provide a more complete set of findings, is appropriate in ensuring credibility to its findings.

Figure 5 illustrates the research design flow chart and how it relates to the adoption of triangulation. In the figure, the relationship between the different stages of the research design is also shown.

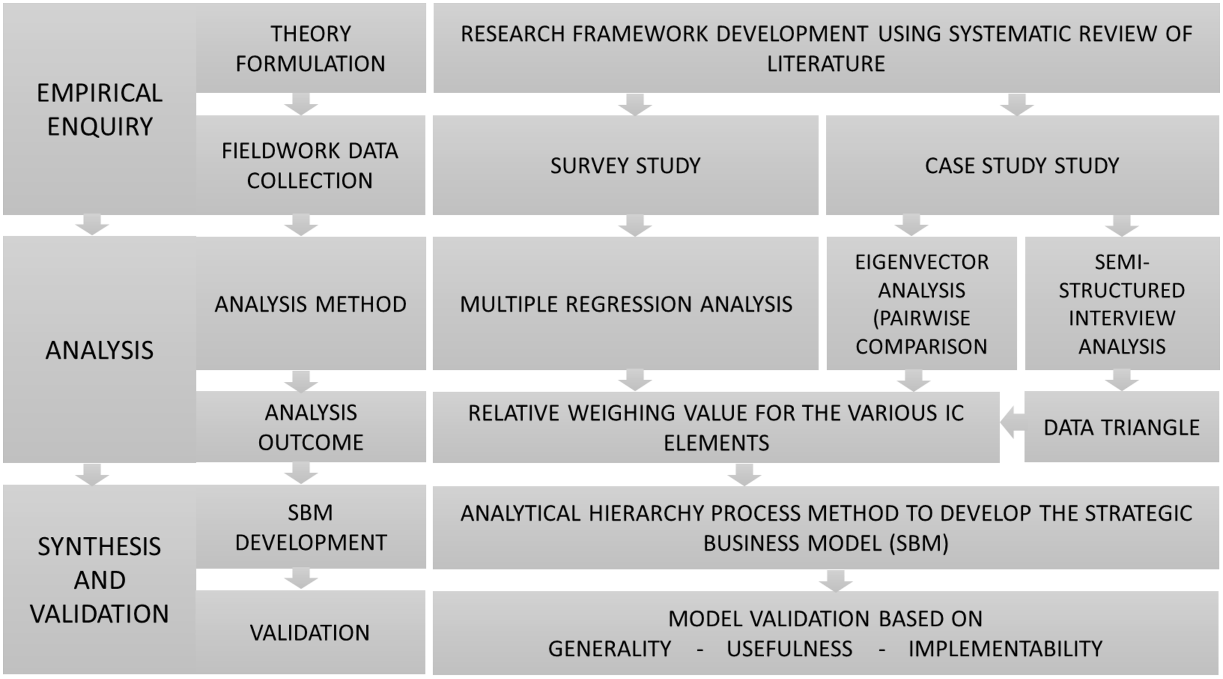

Figure 5: Research design flow-chart

2.4 SURVEY METHOD

The rationale for the selection of this method was as follows:

1. It is an efficient data collection mechanism where the study knows what is required and how to measure the variables of interest. Field studies, comparative surveys and experimental designs often use questionnaires to measure the variables of interest (Sekaran, 2003).
2. Quantified information is required concerning a specific population on the different characteristics of the SME architectural firms.

Sekaran (2003) suggested that an advantage of the questionnaire method is that administering questionnaires to large numbers of individuals simultaneously is less expensive and less time consuming than interviewing. Nevertheless, there are some problems associated with this method that relate to issues of confidentiality (Longacre Jr & Hussey, 1997). Consequently, the study used participant consent information to inform and confirm with participants that the data collected were strictly anonymous and confidential. Furthermore, although questionnaires can be personally administered by hand delivery or by mail, the later technique was not used due to mail inefficiencies in Nigeria (Kori, 2013). Thus, hand delivery was mainly used to collect the primary data for this research.

2.4.1 THE SURVEY QUESTIONNAIRE DESIGN

A survey questionnaire design is a critical stage in the study. Accordingly, Sekaran (2003) outlined three main areas of focus for consideration when designing a questionnaire. These are; the wording of the questions, planning how the variables will be categorised, scaled, and coded after receiving the responses, and the general appearance of the questionnaire. Another critical aspect of designing questionnaire is the rationale and the purpose of the study (Ticehurst & Veal, 2000).

Thus, a questionnaire is a list of carefully structured questions, chosen after considerable testing with a view to eliciting reliable responses from a chosen sample (Hussey & Hussey, 1997). The evaluation framework developed from the literature review significantly guided the questionnaire design process. Questions were integrated into the questionnaire only when they relate to the research objectives and the evaluation framework. Some elements of questionnaires from previous studies were selected as part of the questionnaire design process; this is because they were considered relevant to the study and for further data analysis.

2.4.2 PRE-TESTING THE QUESTIONNAIRE

This stage involved running a trial of the questions with a small group of respondents with the purpose of identifying issues related to the questionnaire's design, structure and instructions. This aimed to minimise any subsequent difficulties amongst participants in understanding the questions; it also aimed to remove ambiguities, and any leading or biased questions (Sekaran, 2003). The pre-testing objective was to evaluate the items used in the design questionnaire (Hair et al, 2006). Pre-testing, with the purpose of refining a measuring instrument, may rely on colleagues, respondent surrogates, or actual respondents (Cooper & Schindler, 1998).

In this study, the first pre-testing of the questionnaire was conducted in September 2015 during an internal workshop event on BIM at the University of Liverpool. This was chosen because it allowed for feedback from experts in the field. Samples were drawn from the workshop attendees and involved 26 interested participants who were mostly PhD students studying BIM-related research. The pretesting exercise involved distributing the initial version of the questionnaire to the participants at the event, and responses and suggestions were collected from 21 respondents. The suggestions highlighted some potential problems with the wording or measurement, and ambiguities; indeed, it is important to give careful consideration to question wording because this substantially influences data accuracy (William, 2003). A basic statistical analysis was conducted on the responses after which the questionnaire was significantly revised and improved following the respondents' suggested wording changes and comments on the inappropriate sequencing of the questionnaire design.

2.4.3 PILOT SURVEY

A pilot study is conducted to detect weaknesses in the instrument design and to provide proxy data for selection. Its purpose includes testing the wording and sequencing of questions (Ticehurst & Veal, 2000). Also included in a pilot test is the questionnaire layout, its familiarity with respondents, the testing of fieldwork arrangements (if required), the training and testing of fieldworkers (if required), an estimation of the response rate and the interview or questionnaire completion time, and the testing of the analysis procedures. It should draw subjects from the target population and simulate the procedures and protocols that have been designed for data collection.

Thus, in this study, the pilot survey was carried out in September 2015 with a target population of 100 firms in Nigeria. Initially, the study proposed an online survey questionnaire to collect the data because the study has previously used such techniques and recorded a positive response (Kori, 2013) from the same sample. Consequently, the pilot study involved the use of an online-survey with software developed by the University of Liverpool; the instrument was administered by email to 100 SME architectural firms in Nigeria. Following a request from the study, the Architectural Registration Council of

Nigeria (ARCON) provided the email addresses. However, after two weeks, only an 11% response rate was recorded. A further resend was issued to the remaining non-respondents as a reminder, but after an additional two weeks this only increased the response rate by 2%. In light of this issue, the study adopted a hand-delivery distribution method for the main data collection.

However, the data from the 13% who responded were still used for the pilot study. Data analysis was conducted to test the reliability and validity of the instrument. On reviewing the results from the reliability tests, validity tests, and some basic data analysis, some minor changes were made to the questionnaire design to improve understanding. It was clear that the pilot could be useful in testing all aspects of the survey including the method of administration as well as the wording and design (Ticehurst & Veal, 2000).

After the data were collected, a reversed scoring was performed for the negatively worded items, the data was analysed using preliminary basic statistical methods in SPSS, and the respondents' feedback was summarised. Any biases could also be detected where respondents had responded similarly to all items or stuck to only certain points on the scale (Sekaran, 2003). The feedback and data analysis indicated some problems with the original survey, so further revisions were made; after this, the study proceeded to the main survey. The next two sections consider the reliability and validity of the instrument.

2.4.4 POPULATION

The population of a study is defined as the entire population of the sample that a study is meant to represent (Sekaran, 2003). In this study, the population represents the SME architectural firms that are registered with the Architects Registration Council of Nigeria (ARCON), which is the regulating body of architectural practice in Nigeria. A consent letter was obtained from the council before carrying out the research. The council also provided a database document containing the contact details of all the registered architectural firms in the country. The email addresses used during the pilot online survey were also obtained from the document. Subsequently, the contact details that were used for the final questionnaire were also obtained from the document.

According to the document, there are 641 registered firms in Nigeria. However, because the study deals with only firms that already have IT-enabled practice, it was necessary to review previous studies to identify where cities significantly differ regarding IT-enabled practice. Consequently, nine cities, comprising Abuja, Lagos, Kaduna, Kano, Port-Harcourt, Maiduguri, Jos, Bauchi and Ibadan, were identified to constitute over 86% of architectural firms that have a record of IT-enabled practice (Oluwatayo, 2009; Kori, 2013). Additionally, the data obtained from the document provided by the council also shows these nine cities constituted about 65% of the entire population of architectural firms in the country.

2.4.5 SAMPLE SIZE

Sampling design and the sample size are important in order to establish the representativeness of the sample and its generalisability. Sekaran (2003) and Roscoe (1975) proposed the following rules for determining an appropriate sample size:

- Sample sizes larger than 30, and less than 500 are appropriate for most research.
- When samples are to be divided into sub-samples, a minimum sample size of 30 for each category is necessary.
- In multivariate research, the sample size should be several times (preferably ten times or more) as large as the number of variables in the study.

A sample is a subset of the population, comprising some members selected from the population. In this study, the population could be narrowed to the number of architectural firms in the nine cities that use IT-enabled practice in their firm. Hence, the estimated possible sample number for this study was decided according to previous studies conducted in the context (Oluwatayo, 2009; Kori, 2013). Thus, the possible sample size of this study should be 86% (the percentage of firms using IT-enabled practice in the nine cities) of 65% (the percentage of the population of architectural firms to the entire population in the nine cities) of 641 (the total population) = 358 subjects. However, because the sample size is already small for this study, it was important to use all subjects in the population as targets. As such, this involved contacting all the firms in these nine cities, and because some of the addresses on the database were either incorrect or outdated, 351 questionnaires were administered within the duration of the study.

2.4.6 DATA COLLECTION AND RESPONSE RATE

The data collection in this study involved administering the questionnaire by hand because the pilot study that used online survey software had a poor response rate. The data collection was carried out between October and December 2015 when 351 questionnaires were administered to SME architectural firms in the cities where the sample population were drawn. Telephone calls, regular visits and emails to the firms were used to track the progress of the surveys. At the end of December 2015, 228 usable questionnaires were collected and used for the analysis. Thus the response rate for the study was 65%

2.4.7 DATA EDITING AND CODING

Data editing and coding is the next step after the fieldwork data is collated. This step enables data storage for direct analysis (William, 2003). In this study, the SPSS software was used for the data analysis and the data edited by checking and adjusting for errors, omissions, legibility and consistency to ensure completeness, consistency, and readability. This was achieved by using the 'frequency distribution' in SPSS. Data was coded by assigning character symbols (mostly numerical symbols) and edited before it was entered into SPSS. Each question or item in the questionnaire had a unique variable name.

A coding sheet was used to keep information on how each variable was coded. It comprised a list of all variables in the questionnaire, the abbreviated variable names that were used in SPSS, and the way in which the responses were coded. To improve the data management, data screening and cleaning were carried out before proceeding to the principal data analysis stage. This was to ensure that there were no (mainly) human errors at the keying data stage. By using descriptive statistics in SPSS (such as frequency analysis), the data was screened by checking each variable to see if the score was out of range for this category (checking frequencies), or for continuous variables (checking minimum, maximum, mean and standard deviations). When errors were identified, the questionnaires were first revisited to confirm the data before correcting the error in the data file. After correcting errors, the study proceeded to the main data analysis stage.

2.4.8 ANALYSIS METHOD

In this study, the independent variables included the forty-nine indicators of the theoretical model categorised under thirteen components. While each component with its indicators served as an independent regression model throughout the analysis, the dependent variable remained the BBVC. To examine the relationship between these components and the BBVC, a multiple linear regression and correlation analysis was conducted to assess whether the independent variables predict the dependent variable (criterion). A multiple linear regression assesses the relationship between a set of dichotomous, or ordinal, or interval/ratio predictor variables on an interval/ratio criterion variable (Solutions, 2013) . Hence, the following regression equation (main effects model) was used for each component as a regression model:

$$\mathbf{y = b_0 + b_1x_1 + b_2x_2 + \ldots\ldots. + b_nx_n + e}$$

Where, y = estimated dependent variable (BBVC)

e = constant (which includes the error term),

b = regression coefficients and

x = each independent variable (the individual indicators (predictors) of the component)

n = number of indicators under a component.

A standard multiple linear regression, called 'the Enter' method, was used for the SPSS analysis. In this method, the user enters all independent variables (the indicators under the particular components) simultaneously into the model. Variables were evaluated by what they add to the prediction of the dependent variable, which is different from the predictability afforded by the other predictors in the model (Nach, 2009) .

In order to test the component level hypotheses in terms of whether there is a significant linear relationship between the individual components in the theoretical model and the dependent variables, the F-test was used. It involved testing whether the set of the independent variables (indicators) collectively predicts the dependent variable for that particular component. The 'R-squared' multiple correlation coefficients of determination were also reported and used to determine how much variance in the dependent variable can be accounted for by the set of the independent variables. The t-test was used to determine the significance of each of the indicators and beta coefficients were used to determine the magnitude of prediction for each indicator variable. For significant predictors, every one-unit increase in the predictor, meant the dependent variable will increase or decrease the number of unstandardised beta coefficients (Statistics Solutions, 2013).

By examining a scatter plot for each of the 13 regression models (components), the assumptions of multiple regression linearity, homoscedasticity and multicollinearity were assessed. The absence of multicollinearity in all assumes that predictor variables are not closely related. Hence, the models are valid for analysis (Solutions, 2013). Therefore, according to Figure 15: Theoretical model for the BIM-based innovation showing the hypotheses formulated for analysis

which is in Chapter 4 of the survey analysis, the analysis involved a separate analysis of 13 regression models conducted under the four capitals. The HC aspect involved three components, the RC with four components, the SC with three components, and the KC with three components.

2.5 CASE STUDY METHOD

The case study is central to two issues; firstly, in identifying the different ways in which firms with BIM capabilities develop their IC to achieve BBVC. This is realised by conducting and analysing semi-structured interviews with six architectural firms in the Nigerian AEC industry with relatively advanced BIM capabilities. The result is to be compared with that of the survey results to check the reliability and validity of the data and this will ultimately form the data triangle. Secondly, the case study aims to identify the RWV for the different elements of the IC and the extent of their contribution to the BBVC. This was achieved using a pairwise comparison analysis, which was carried out by the same firms involved in the interviews.

2.5.1 DATA COLLECTION

During the administration of the survey questionnaire, the SME architectural firms were asked if they would be interested in participating in the focus group, and 23 firms indicated interest. When given short additional questions on their BIM capabilities, only six firms qualified and were thus contacted for the case study interviews. Hence, it is believed that these six firms are relatively advanced with regard to BIM adoption.

2.5.2 DATA TRANSCRIPTION

The interview discussions were transcribed and entered into the NVIVO software. The software was used for analysing the semi-structured interviews. Furthermore, the pairwise comparison questionnaire was used for the Eigenvector analysis, and an AHP Excel Template used with Multiple Inputs developed by (Goepel, 2013a).

2.5.3 DATA ANALYSIS TECHNIQUES

The goal of conducting the case study analysis is to identify the various techniques used by the SME Architectural firms with relatively high BIM capability to achieve BBVC. It is for this reason, the study employs thematic analysis method for analysing the interview data. Braun & Clarke, (2006) defined thematic analysis as a method for systematically identifying, organising, and offering insight into patterns of meaning (themes) across a dataset.

The study uses this method to focus on the meaning across the dataset of each of the interviews, as through this method (Thematic analysis) the study is allowed to see and make sense of collective or shared meanings and experiences (Braun & Clarke, 2006). The method also allows the study to identify what is common to the way the issues of the IC development is discussed in the interview, and making sense of those commonalities.

However, Braun & Clarke (2006) suggested that what is common is not necessarily in and of itself meaningful or important. Hence, in this study, the patterns of meaning for each theme that is identified were found to only be important in relation to the IC development variables and relevant to the research question of the study.

The analysis involved the six phases as suggested by (Braun & Clarke, 2006). This process of which is not necessary linear rather a recursive process as employed by the study. These phases are as follows:

1. Familiarisation with the data: The study first started by familiarisation of the data set as a whole for the 6 case study interviews and as for each of the case study interviews. This is first through inputting the whole interview transcript in the Nvivo software and then going through reading and re-reading the data (and listening to audio-recorded data at least once, if relevant) and noting any initial analytic observations.
2. Coding: In Nvivo, this is done through nodding, a method of coding data in the Nvivo software. This involves generating pithy labels for important features of the data of relevance to the (broad) research question guiding the analysis. Coding is not simply a method of data

reduction, it is also an analytic process, so codes capture both a semantic and conceptual reading of the data (Braun & Clarke, 2006). In this study, the study put a node in every data item and ends this phase by collating all their nodes and relevant data extracts in the Nvivo software.

3. Searching for themes: A theme is a coherent and meaningful pattern in the data relevant to the research question. Searching for themes is a bit like coding your codes to identify similarity in the data. This 'searching' is an active process; themes are not hidden in the data waiting to be discovered by the intrepid study, rather the study constructs themes. The study ends this phase by collating all the nodes in the Nvivo software relevant to each theme.

4. Reviewing themes: This involves checking that the themes 'work' in relation to both the coded extracts (nodes) and the full data-sets of the interviews. In each case, the study reflected on whether the themes tell a convincing and compelling story about the data before beginning to define the nature of each individual theme, and the relationship between the themes. In some cases, it was necessary to collapse two themes together or to split a theme into two or more themes, or to discard the candidate themes altogether and to restart the process of theme development.

5. Defining and naming themes: This involves the phases where each of the themes identified is finally named and defined in relation to the literature of the IC development. It involves checking each theme against the various indicators initially found in the literature and where, there is none conformity, those were identified as new indicators from the case study analysis.

6. Presentation: This involved the use of the Treemap charts produced from the Nvivo, it helped in presentation the data set against the variables of the initially identified through the literature and survey.

2.5.4 CASE STUDY DESIGN

The case study analysis involved a two-stage evaluation;

1. **Semi-structured interviews**

   The primary objective of this stage was to identify the indicators of the thirteen components of the IC through an exploratory study. The primary purpose was to provide data triangulation to ensure the reliability and validity of the study. In this stage, firms were presented with a brief explanation of the evaluation framework. They were then presented with the four capitals and the thirteen components identified through the literature. The main objectives were to provoke discussion on whether the firms recognised this component and how they captured and developed it to form BBVC. The questions were divided into four sections.

i) *The Human Capital* aspect provoked discussion on how the firms develop motivation and capability through their HC to adopt and use BIM technology and create business value. Three questions were posed under this section on the particular qualities and criteria that the firm considers essential in the development of motivation and capability through their ‘IT manager', ‘top manager' and ‘general employees'; these formed the three components of the HC.

ii) *The Relationship Capital* aspect provoked discussion on how the firms develop motivation and network resources from their RC to adopt and use BIM technology and create business value. Four questions were posed under this section concerning what specific steps and criteria the firm considers essential in the development of motivation and network resources through their relationship of internal, external, environmental and image and reputation aspects; these formed the four components of the RC.

iii) *The Structure Capital* aspect triggered discussion on how the firms develop motivation and capability through their SC to adopt and use BIM technology and create business value. Three questions were posed under this section on what specific qualities and criteria the firm considers essential in the development of support and capability, through their system, infrastructure and process aspects; these form the three components of the SC.

iv) *The Knowledge Capital* aspect generated discussion on how the firms develop motivation and capability through their KC to adopt and use BIM technology and create business value. Three questions were posed under this section on what specific qualities and criteria if any the firm considers essential in the development of knowledge resources through their exploration, retention and exploitation channels; these formed the three components of the KC.

It is assumed that, during this discussion, the firm would reference the different indicators they considered essential in defining the various components presented. The process would later allow for a triangulation with the survey result, which would help to ascertain the reliability and validity of the survey results.

2. Pairwise Comparison

The main objective of this stage was to identify the relative importance of each of the thirteen components of the IC. This accorded with the second objective of the study, namely to identify the critical elements through the management and optimisation. Since the interview discussions encouraged the interviewees to explore knowledge of each of these components, it was believed that their judgement could be valuable in predicting the RWV of each component. Thus, a pairwise comparison template (Appendix 1: Pairwise) was presented to the firms to calibrate the relative importance of each set of components. Each component discussed in the interview was compared and their relative importance weighted. The outcome provided both the RWV of the components and the four IC elements.

The pairwise comparison method involved the calculation of the RWVs based on the firms' questionnaire answers. This method was conducted using a Microsoft Excel spreadsheet. As previous research suggested (Saaty, 2008), three steps were employed, which were:

(a) Using questionnaire results to insert the data in Excel, and building binary comparison matrices for each level of the hierarchical structure;

(b) Calculating the RWVs:

- (b.1) Calculating the sum of each column of the matrix;
- (b.2) Dividing each element of the matrix by the sum of the corresponding column, and obtaining a new, standardised matrix;
- (b.3) Calculating the average of each line of the standardised matrix (sum and divide by n variables considered), obtaining the column vector "w" (RWV), where the sum of the vector must equal 1;

(c) Verifying the matrix consistency:

- (c.1) Multiplying the sum of each column of the original matrix (step b.1) by vector "w" (step b.3), and thus obtaining a new vector (consistency measure);
- (c.2) Assuming the matrix is consistent, the vector calculated in step c.1 will have values ideally equal to 1.

According to (Saaty, 2008), the rule of the thumb for the pairwise comparison was that the analysis should have a consistency ratio of 10%. However, other studys suggested that a consistency ratio of 15% is also acceptable (Ho et al, 2005). Hence this study considered that below 15% was the threshold for analysis. The presentation for the paired comparison was provided through the matrix table, which also provided the details regarding consistency, based on the Eigenvector recommendation.

2.6 CHAPTER SUMMARY

The study was designed in three stages, empirical enquiry, analysis and synthesis. The empirical enquiry comprised of theory formulation and fieldwork data collection. The theory formulation was achieved through proposing an evaluation framework using a systematic literature review on the four IC elements. The evaluation framework constituted a set of independent variables comprising thirteen components categorised under the four elements. Each component was defined by a set of indicators, and the proposition suggested a relationship between these indicators, the components of the IC, and a dependent variable of the BBVC.

The evaluation framework was used to collect data from the fieldwork. It involved a questionnaire survey and case study interviews with a sample of SME architectural firms in Nigeria. The survey involved administering questionnaires by hand to 351 firms within nine cities in Nigeria during September 2015. It yielded 228 completed questionnaires by the end of December 2015. The six case study interviews were also conducted within the same period. The survey data enabled the evaluation of the framework using a multiple regression analysis. Each component and its sets of indicators represented an independent model of regression in the analysis. The outcome provided statistical evidence of the relationship between the two main variables. Also, it provided the Relative Weighting Value (RWV) for each of the indicators on the components and their effects on the BBVC.

The case study analysis was used to triangulate the data from the survey results and provide the RWV for the components and the four IC elements. The case study involved six SME architectural firms that have a relatively high BIM capability; these were drawn from the survey sample during the administration of the questionnaire. The case study analysis was carried out using two approaches: firstly, an exploratory study of semi-structured interviews based on the themes of the thirteen IC components to identify the different indicators employed by the firms during the BBVC. This was analysed using the NVIVO software. Secondly, the Eigenvector method was used to analyse a pairwise comparison where each component discussed in the interview was compared and weighted in terms of their relative importance. The outcome established the reliability and validity of the survey data as well as the RWV of the thirteen components and the four IC elements.

3 CHAPTER THREE: RESEARCH FRAMEWORK

3.1 CHAPTER OVERVIEW

This chapter discusses the theory formulation of the study, which is a step in developing a theory that incorporates all the relevant factors contributing to the research problem. It integrates all the information from the literature review in a logical manner, hence is a collection of theories and models that help to conceptualise and postulate an evaluation framework to guide the study that explains the research questions, and clearly identifies and labels the variables (Chao-Chien, 2011). This chapter is developed from the Chapter One discussions about the evaluation framework.

3.2 THE VARIABLES: INTELLECTUAL CAPITAL (IC) DEVELOPMENTS AND BIM BUSINESS VALUE CREATION (BBVC)

There are two types of variable in this study, namely dependent and independent. The dependent variable is the measure of successful BIM adoption in SME architectural firms, which is termed BBVC (BIM Business Value Creation). The discussion about the dependent variable is presented under Section 3.4. The second type is the independent variable, meaning the measure of the different ways in which SME architectural firms capture, develop and integrate their Intellectual Capitals; these are discussed in Section 3.3. Figure 6 illustrates the interrelationships between these variables, which is based on the discussion in Chapter One.

The study identified four capitals as the point of departure for identifying the different ways in which SME architectural firms develop and integrate their Intellectual Capitals, which are Human, Relationship, Structure and Knowledge Capitals. These capitals, however, are comprised of different elements, which are also critical to understanding any impact on the BBVC. Section 3.3 on independent variables discusses this critical element. The outcomes from the discussion in Chapter One helped in formulating the hypothesis for this study. These hypotheses were tested in the survey analysis, through multiple regression. Furthermore, the case study presented in Chapter Four takes an exploratory approach that complements the theory formulation and survey analysis. The overall approach forms a data triangle, which is used to reinforce the reliability and validity of the study.

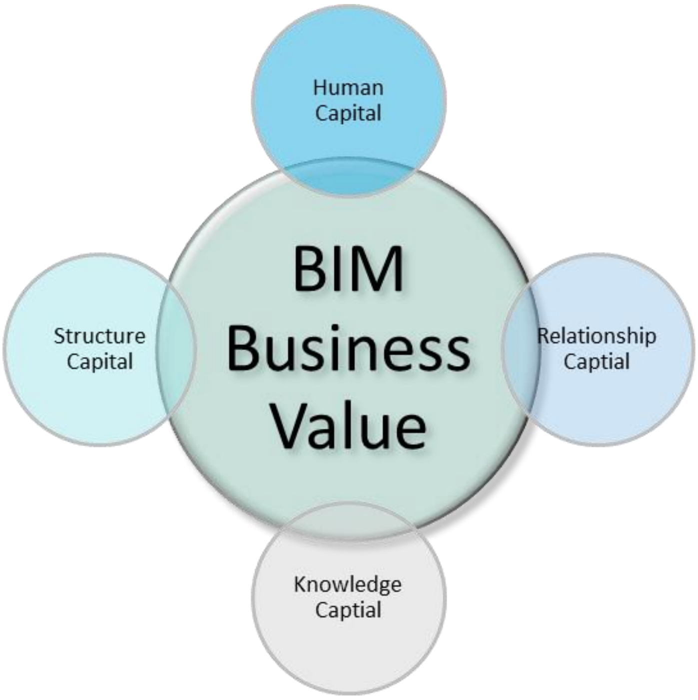

Figure 6: The relationship between the variables of the study

3.3 INDEPENDENT VARIABLES: A MEASURE OF INTELLECTUAL CAPITAL DEVELOPMENT IN SME ARCHITECTURAL FIRMS

The independent variables shown in Figure 6 represent the four capitals. The main goal in this section is to identify the different components and elements from the literature review.

This was achieved through a systematic review, where literature on each of the four elements of the IC is reviewed and explored, which are:

1. Human Capital (HC)
2. Relationship Capital (RC)
3. Structure Capital (SC)
4. Knowledge Capital (KC)

3.3.1 HUMAN CAPITAL (HC)

The development of the HC of an SME architectural can be defined as the process of leveraging the qualities of firm's human resources, specifically through motivation and capability to innovate in small professional practice (Lu & Sexton, 2009) . These human resources involve individuals within the SME architectural firm, the client's systems, and the external supply chain partners coming together to perform productive, professional activities in a broad range of situations (Lu & Sexton, 2009). The BIM adoption process is integral to this position and can be affected by HC development. This particularly applies to SME architectural firms that rely heavily on the development of HC to innovate (Barber & Manger, 1997). Rabey (2000) suggested that the HC of an SME architectural firm can be the sum of the competence, compliance and commitment of their human resources. Hence, the composition of human knowledge, skills and attitudes serve productive purposes in the firm (Scarbrough, 2003). Moreover, Cabrita et al (2007) advocated that the HC of a firm comprises anything associated with the human resources that contribute to the firm's routine of activities. This includes the tacit knowledge, skills, experience, and attitude of the firm's human resource. HC can be seen as a primary tool for an organisation to learn, by influencing the ability to acquire new knowledge (Kang & Snell, 2009). The study of HC has been emphasised over the other forms of IC (Alcaniz et al (2011) which has significant implications for how enterprises employ and grow their HC resources. All these definitions are alike in emphasising that HC represents staff motivation and the capability to undertake directed, productive work.

As the BIM adoption process involves human resources that engage in communication and collaboration in a digitally mediated environment, Jaradat et al (2013) emphasised the need to consider the ways in which HC is developed (Sexton & Barrett, 2003). García-Morales et al (2007) suggested that those involved in innovation activities usually demonstrate particular personal qualities that inform their capability and motivation to innovate. These qualities include expertise and skills, the ability to influence clients, and to perform knowledge-intensive tasks. Therefore, to investigate the impact of HC on BIM innovation, it is crucial to understand the different individuals involved in the adoption process (Lu & Sexton, 2009). Holzer (2015) suggested three main 'players' involved in BIM adoption in small construction firms, and these are the BIM Manager, the Top Manager and the employees; furthermore, Holzer argued that a firm does not change until the individuals within it change.

Yang & Lin (2009) and Morris & Snell (2011) emphasised that HC development comprises the utilisation of the knowledge, skills, experience, and abilities of individuals in a firm to achieve the organisational outcomes. However, they suggested that experience is the most important component in the process, in that the collective experience of the members of a subunit or team can be considered an indicator of the level, as well as the type, of HC involved (Karchegani et al, 2013). This is based on the idea that individuals work, or are educated in, certain situations and gain experiences that result in a HC that can be applied to execute specific responsibilities (Morris & Snell, 2011). Such individual knowledge and experience serve as the source of ideas and knowledge creation in their organisations (Nonaka & Takeuchi, 1996). Hence, the manner of HC development can be understood through the identification of the different elements that make up the development. Nevertheless, when explaining the nature of HC for firms within New Growth Theory Thornhill (2006) suggested that it is a source of innovation and renewal. The competencies, attitudes and intellectual agility of a firm's human resource can be used to understand these elements. However, Karchegani et al (2013) emphasised that, competency is the most frequently cited element of HC. Alternatively, HC has also been defined as comprising six elements: educational levels, job-related licences or qualifications, job-related knowledge, job potential, personality traits, and job-related abilities (Yen, 2013). Furthermore, Karchegani et al (2013) proposed that HC development could be inclusive of the knowledge, skills, attitudes and intellectual agility of employees. Nevertheless, Kang & Snell (2009) suggested that specific knowledge and skills can, within a narrower range of parameters, represent the most effective acquisition and assimilation of new, in-depth knowledge.

Studys in the field of Organisational Learning, suggested that organisations do not create knowledge themselves (Kappler (1980), Nonaka (1994)), which implies that human resources are the source of knowledge creation. Individuals in organisations are the ones who question prevailing norms and search for solutions that are fundamentally different from preserved knowledge, in order to deal with existing problems (Subramaniam & Youndt, 2005). Therefore, HC is considered crucial in increasing the ability to absorb and use knowledge from a myriad of domains.

Based on the above discussion, this study identified three components that comprised the development of HC in SME architectural firms. These components are based on the individuals that play a role in the BIM adoption process. Managing the change process associated with implementing BIM at the process level can be emphasised within integrated project delivery, design intent validation, and lean design management. These three components are as follows.

1. The motivation and capability of the IT manager
2. The motivation and capability of the top manager
3. The motivation and capability of external professional partners

Since the goal of the research is to determine the empirical relations between these components and success in the BIM adoption process, there is a need to identify the indicators/predictors under each component through elaborating the definitions presented above. A discussion on the identification of indicators for each of the above components is presented in the following sections, and in each case, the hypothesis and sub-hypothesis of the case are formulated and presented.

3.3.1.1 MOTIVATION AND CAPABILITY OF IT MANAGER

IT Managers play a decisive role as change facilitators in the BIM adoption process (Holzer, 2015) and their motivation and capability can be crucial for innovation in SME architectural firms (Lu & Sexton, 2009). Hence, as change facilitators, IT managers assist key stakeholders within an SME architectural firm by mentoring them on their path to deal with change. Holzer (2015) emphasised the relevance of the IT manager in driving BIM innovation stressing that they need to base their work on a strong awareness of the situations they encounter within their organisation and beyond. They are the ones who understand the broader industry context when it comes to technology uptake and its reconciliation with existing practices. They empower them to engage with a changing context that affects their professional and personal life. Hence, the IT manager in this context can be defined as the staff responsible for leading technology innovation in the firm. For the BIM adopter, this could be the BIM manager, while for non-adopters, this can be any individual who champions, or is responsible for, leading IT activities in the firm.

In this study, four indicators have been identified to form the variables or predictors in determining the motivation and capability of the IT manager in an SME architectural firm, and these are; the nature of employment, higher education qualifications, experience, and job satisfaction. With regard to the nature of employment, (Malhotra et al, 2016) suggested that the creation of new roles and career paths in order to allow for flexible working and better work-life balance does not only accommodate staff needs, but can help make businesses more innovative. They argue that, while SME architectural firms find it challenging to change working practices in response to staff demands for flexibility, the study, which involved law firms in London, shows that taking a proactive, creative approach to work-life balance and career-pathing can benefit a firm's longer-term competitiveness. In doing so, the firm not only helps to retain the valuable talents of their employees to exploit innovation but, by organising it in new ways, their ability to deliver the innovations that their client seeks is enhanced (Malhotra et al, 2016). This applies, in particular, to the BIM adoption process where innovation is driven more by people and knowledge than the technology infrastructure. Their study confirms the relationship between the nature of the change facilitator's employment and the motivation and capability of the firm to innovate.

Innovation in a knowledge-intensive firm emerges from practice, through people with various kinds of knowledge and experience coming together to address the new and different challenges presented by their clients (Malhotra et al, 2016). However, this proves difficult under the traditional design process of AEC firms where the firm hierarchy is required to make compromises between the time spent mentoring and the sharing of specialised knowledge. For example, this involves standing back and looking at existing processes in different ways, building relations with clients, winning new and attractive jobs, and achieving stringent targets for billable hours. Malhotra et al (2016) argued that firms that can alleviate these compromises and smooth the path to both operational and technical innovation, which can help to generate new, cutting edge solutions and to roll them out with greater efficiency and at a lower cost. Hence, the nature of the employment of the IT manager may also be a predictor of the BIM adoption success.

With regard to educational attainment and experience, Baldwin & Johnson (1996) argued that the most innovative firms offer more formal and informal continuous training and have more innovative human resource policies, implicitly recognising the relevance of HC to their performance. Yang & Lin (2009) and Morris & Snell (2011) emphasised that the experience of the individual employee responsible for innovative activities is the most crucial part of HC development in terms of enhancing innovation in a firm. In fact, the knowledge specificity and the speed of change associated with innovation demand permanent growth in the competency levels of employees, requiring high degrees of motivation and their participation in the decision process. Becker (1994) examined the consequences of investing in a person's knowledge and skills through education and training.

Educational attainment and experience form the competency of a manager (Baldwin & Johnson, 1996) and they are a major factor in innovation success (McGuirk et al, 2015). This assertion has also been confirmed by Hayton (2005) who added that cognitive resources, along with experience and values, were found to have a significant influence on the way managers comprehend and interpret organisational stimuli, and thus on their problem-solving capabilities. Considering their influence through their decision power in the innovation processes, the existence of these HC indicators for the IT manager's component may be crucial to the innovation capabilities and motivation of the firm and may, in turn, influence the BIM adoption process.

The competency of the IT manager, who is responsible for guiding the implementation process of innovation, can be measured by the level of educational attainment and experience; a study by Toner (2011) has shown that there is a strong relationship between higher levels of education and technical training and an increased demand for the supply of technical and organisational innovation. For example, Romer (1990) measured HC by assessing the cumulative effects of formal education and on-the-job training. While the latter can be limiting, it is easily measured; hence, the technical, or on-job, training can also be defined as the education attainment of the IT manager. The OECD report (OECD, 2011) suggests an array of skills required for innovation, including basic and digital literacy, and academic and technical skills; however, education and technical skills remain an essential prerequisite to innovation.

Furthermore, with regard to job satisfaction, Binder & Coad (2013) suggested that work is an important part of human life and has a strong effect on a person's happiness or satisfaction.

Job satisfaction is widely studied in the context of organisational behaviour (Zhou & George, 2001). Moreover, in a study on the effect of aggregate job satisfaction and organisational innovation in firms, job satisfaction was found to be a significant predictor of innovation, suggesting that employees who experience job satisfaction will support rather than resist innovation (Shipton et al, 2005). However, in another context, a study on creativity in organisations examined the conditions in which employee job dissatisfaction might lead to creativity (Zhou & George, 2001). This study involved 149 office employees from a manufacturing firm and found that those who were dissatisfied with their jobs but committed to remaining in their position found that they made improvements in their workplace that resulted in increased creativity.

3.3.1.1.1 Hypotheses and Sub-Hypotheses: Motivation and Capabilities of the IT Manager

From the above discussion, the study formulated the following hypotheses for empirical study which is also illustrated in Figure 7:

$H1_1$: The motivation and capabilities of the IT manager toward innovation in SME architectural firms has a significant relationship with BBVC.

$H1_0$: The motivation and capabilities of IT manager toward innovation in SME architectural firms has no significant correlation with BBVC.

Sub-Hypotheses:

- *H1a: Firms that develop their HC innovation from IT managers with a* ***flexible work life*** *are likely to succeed in BBVC.*
- *H1b: Firms that develop their HC innovation from IT managers with* ***higher education qualifications*** *are likely to succeed in BBVC.*
- *H1c: Firms that develop their HC innovation from IT managers with* ***previous IT experience*** *are likely to succeed in BBVC.*
- *H1d: Firms that develop their HC innovation from IT managers with* ***higher job satisfaction*** *are likely to succeed in BBVC.*

3.3.1.2 MOTIVATION AND CAPABILITY OF TOP MANAGER

The motivation and capability of the top manager in informing the innovation level have been emphasised by Lu & Sexton (2009); this suggests that the top manager's involvement in teamwork and their support for innovation is integral to the successful innovation of an SME architectural firm. Teixeira & Tavares-Lehmann (2014) suggested that the particular HC attributes of the top manager occur in the form of specific education and experience, including managerial, commercial and technical experience. These attributes provide positive contributions to a firm's performance and survival, and affect the innovation capability of the firm. However, according to the regulation in most countries, professionals, such as architectural practitioners, often have all the prerequisite educational and professional experiences. Hence, despite the relevance and effects of education and professional qualifications on the performance and innovation of a firm, the duo cannot be used as predictors in understanding the difference between the ways in which the SME architectural BIM adopter and non-adopter develop their HC. Oluwatayo (2009) reiterated this through a study on the impact of top managers' education on the innovation of professional firms in Nigeria; it was found that the level of education of top managers within architectural practices did not necessarily affect a firm's ability to innovate because it is a basic criterion of a role within the profession. Furthermore, Stuart & Abetti (1988) found that the number of chief executives of new technical firms with an education beyond a Bachelor's degree negatively related to firms' performances. Thus, in this study, four indicators have been identified to form the variables or predictors in determining the motivation and capability of the top manager in SME architectural firms, and these are; the strategic knowledge of innovation, non-resistance to change, the ability to inspire others, and teamwork quality.

With regards to the strategic knowledge of innovation and non-resistance to change, Montalvo (2006) emphasised that change is at the heart of innovation. Lu & Sexton (2009) suggested that the top manager's innovativeness and ability to strategically plan innovation is integral to successful innovation in professional SME architectural firms in the AEC. (Hurt et al, 1977) defined individuals' innovativeness as their willingness to change, whilst, Wang & Ahmed (2004) found that the innovativeness of top managers in firms depends on their willingness and ability to change and to encourage new ways of doing things. Wang & Ahmed (2004) also identified a lack of management capability as an obstacle to strategic change on the part of the individual in organisations, along with executives' hesitation to take risks due to the uncertainty of change. Little is known of the issue of willingness to change in small firms and in particular how this impacts on small firms' propensities to innovate. Thus, these two variables indicate a need for empirical enquiry into whether they affect the BIM adoption process. (Karchegani et al, 2013) also suggested that the top managers in a firm are responsible for sustaining, protecting, developing and managing the intellectual capital to increase organisational innovation. Although most studies identified the qualities of the top manager as focusing on planning and being good at administrative routines, Andersson & Tell (2009) argued that they can also be creative and innovative.

With regard to teamwork qualities and the ability to inspire others, the identification was based on the assertion of Lu & Sexton (2009) that these qualities are among the integral motivations and capabilities of firms for successful innovation. This suggested that top managers' abilities to communicate and collaborate effectively can inspire peers and employees to innovate; hence, they can encourage employees to be competitive in idea generation.

3.3.1.2.1 Hypotheses and Sub-Hypotheses: Motivation and Capabilities of the Top Manager

From the above discussion, the study formulated the following hypothesis for the empirical enquiry which is also illustrated in Figure 7:

$H2_1$: The motivation and capabilities of top managers regarding innovation have a significant correlation with BBVC in SME architectural firms.

$H2_0$: The motivation and capabilities of top managers regarding innovation have no significant correlation with BBVC in SME architectural firms.

Sub-Hypotheses:

- *H2a: Firms that develop their innovation HC from top managers with **strategic knowledge of innovation** are likely to succeed in BBVC.*
- *H2b: Firms that develop their innovation HC from top managers with **non-resistance to change** are likely to succeed in BBVC.*
- *H2c: Firms that develop their innovation HC from top managers with **the ability to inspire others** are likely to succeed in BBVC.*
- *H2d: Firms that develop their innovation HC from top managers with **the quality of teamwork** are likely to succeed in BBVC.*

3.3.1.3 MOTIVATION AND CAPABILITY OF EMPLOYEES

Employees in this context refer to any individuals within the SME architectural firm who are not within a top management position and whose activities and effort is relied upon to achieve the routine activities of the firm. Hence, Hayton (2005) and McGuirk et al (2015) provided evidence that the motivation and capabilities of individual employees through their qualities of education, intellect and cognitive abilities are related to higher levels of creativeness and openness to innovation. Also, McGuirk et al (2015) stressed that these qualities could contribute to the efficiency and success of the capability and motivation of human resource management practices oriented at promoting innovation. Shipton et al (2005) argued that sophisticated human resources management focuses on employees' exploratory learning through maximising their abilities to create, transfer and implement knowledge, and that this has been related to improvements in the innovation capabilities of firms. Andries & Czarnitzki (2014) stressed that involving and allowing individual employees to engage with innovation activities might allow for the discovery and exploitation of local knowledge, particularly when there are incentives in place that foster such discovery (Argote, 2012). Lichtenstein & Brush (2001) suggested that employees have the potential to contribute to a small firm's innovation process. Indeed, a study by Love et al (2014) showed that there is a significant percentage of top managers that affirm the potential of their employees in the innovation process. Thus, in this study, four indicators have been identified to form the variables or predictors in determining the motivation and capability of employees in SME architectural firms to innovate and these are; employees with regular training, shared innovative values, willingness to accept changes, and self-motivation.

As regards regular training, (Toner, 2011) stressed that there is a strong association between the on-job technical training of employees and a firm's ability to innovate. Romer (1990) added that the HC of a firm could be assessed through the cumulative effects of formal education and the on-the-job training of its employees. McGuirk et al (2015) suggested that a series of skills is required for innovation, which can include basic and digital age literacy, and academic and technical training skills. However, this emphasises that technical skills can be regarded as a requisite for innovation in the firm. This assertion is also advocated by Becker (2009) who, despite stating that HC is the measure of a firm's investment in its human resource, still suggested that schooling and training courses represent an investment in HC. According to Becker (2009), general training increases the productivity of employees. However, Mincer (1974) argued that schooling alone is not sufficient as a method of training, stressing that graduation from school is rather a preparatory stage of training. Hence, regular training can affect the innovation process in the firm.

With regard to employees' innovative values, Majchrzak et al (2004) suggested that the shared understanding and commitment of employees toward achieving the strategic goal and the firm's vision of innovation significantly affects the innovation capability of the firm. McGuirk et al (2015) also stressed their importance by arguing that a firm whose top managers effectively communicate and are committed to implementing these elements record significant success in their innovation capabilities.

Furthermore, with regard to their willingness to accept innovation, Lu & Sexton (2009) stressed that the more employees in a firm are motivated and open to new ideas, the more innovative and efficient their practices will be. Hence, they emphasised the importance of having employees who are willing to accept innovation. Santos-Rodrigues et al (2010) also confirmed that innovative behaviours, such as employees' willingness to accept new ideas and different ways of doing things, have an impact on the innovativeness of firms. McGuirk et al (2015) presented evidence that the willingness of employees to accept change significantly affects the success of innovation in firms. The study added that such willingness to change includes a commitment to increase the level of technology or computers involved in an employee's work; a willingness to accept change in the level of skills necessary to carry out their job, and increased responsibility among others.

With regard to the self-motivation of employees as a predictor of HC, McGuirk et al (2015) provided some evidence that employees' competencies, values, attitudes and skills are a sum of their self-motivation and a crucial factor in SME architectural firms' innovations. Hence, this can also affect the BIM adoption process. This is particularly true as BIM adoption is characterised as a knowledge absorption and creation process (Sexton & Barrett, 2004). Indeed, firms cannot create knowledge for themselves without the initiative of individual employees (McGuirk et al, 2015) . Firms must have people that know how to (and want to) select, integrate, share and enrich information to create understanding and true knowledge, and turn it into innovation. In that sense, apart from 'formal' competencies, like education, other personal characteristics, such as one's values, attitudes and skills, seem to be equally critical for BIM innovation success.

3.3.1.3.1 Hypotheses and Sub-Hypotheses: Motivation and Capabilities of Employees

Thus, from the above discussion, the study formulated the following hypothesis for the empirical enquiry which is also illustrated in Figure 7:

$H3_1$: The motivation and capabilities of the employees of SME architectural firms regarding innovation have a significant correlation with BBVC.

$H3_0$: The motivation and capabilities of the employees of SME architectural firms regarding innovation have no significant correlation with BBVC.

Sub-Hypotheses:

- *H3a: Firms that develop their innovation HC from employees **with regular training** are likely to succeed in BBVC.*
- *H3b: Firms that develop their innovation HC from employees **with shared innovative values** are likely to succeed in BBVC.*
- *H3c: Firms that develop their innovation HC from employees' **willingness to accept innovation** are likely to succeed in BBVC.*
- *H3d: Firms that develop their innovation HC from employees **with self-motivation** are likely to succeed in BBVC.*

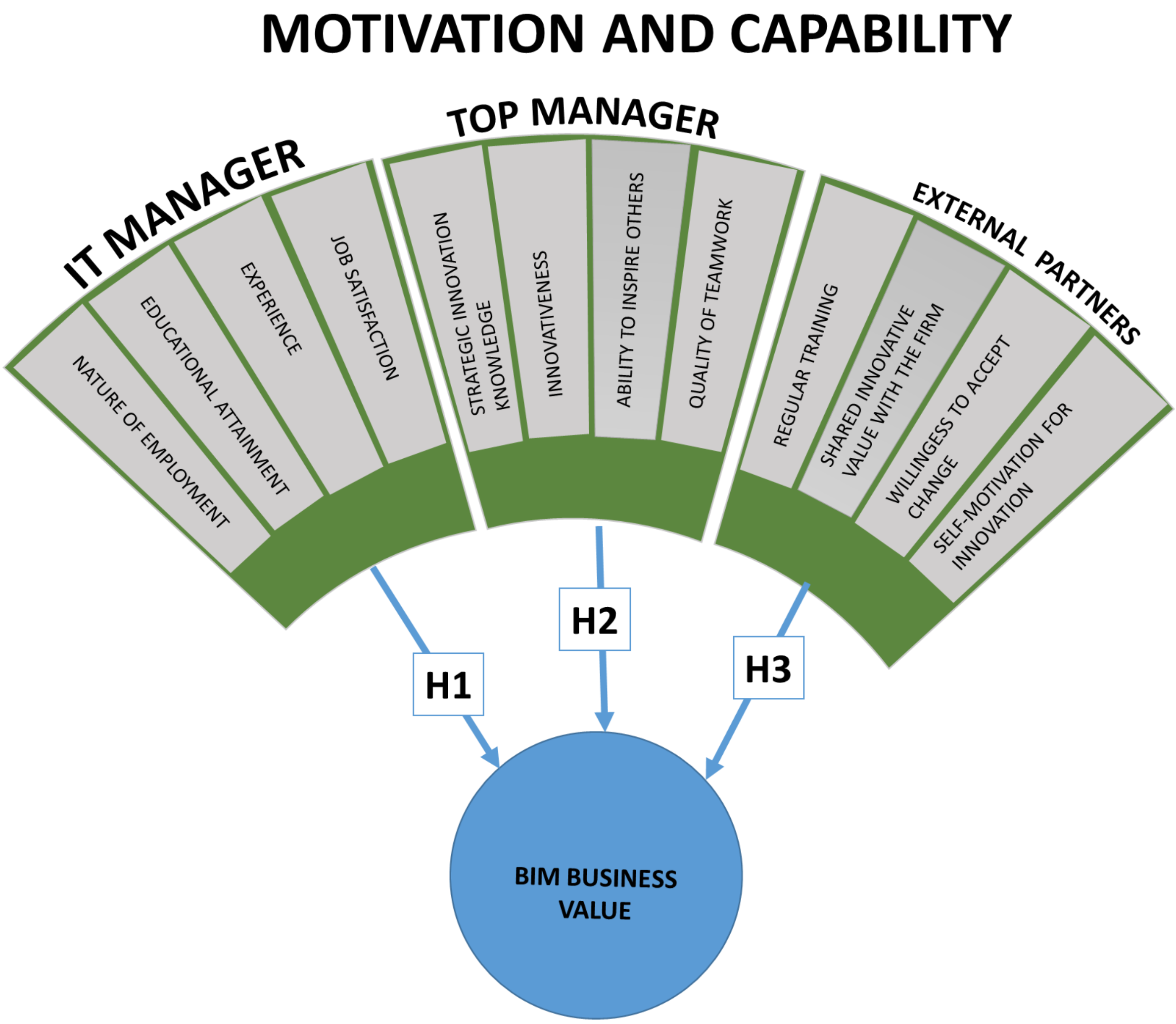

Figure 7: A model for HC components of BIM adoption in SME architectural firms

3.3.2 RELATIONSHIP CAPITAL (RC)

Relationship Capital is also called social capital, (Landry et al, 2002), external social capital (Erik Sveiby, 1997), customer capital (Wiig, 1997), or relational capital (Snyder & Pierce, 2002). It exists in the interactions between individuals and groups, which adds value to their activities. The knowledge resource in RC is largely tacit, composed of cultural norms that exist as a result of working together (Lu & Sexton, 2009). Relationship knowledge is reflected by an ability to collaborate effectively (Lu & Sexton, 2006). However, RC is defined as customer and supplier relationships, knowledge of market channels, and an understanding of the impact of governmental or industry association (Lu & Sexton, 2009); it considers the value derived from connections outside the organisation, and includes reliable suppliers and loyal customers (Snyder & Pierce, 2002). These two definitions confirm that RC resides in the relationship within HC (Fu, 2004). Furthermore, (Fu, 2004) asserted that RC consists of the stock of active connections among people, and the trust, mutual understanding and shared values and behaviours that bind the members of human networks and communities and make cooperative action possible. The social network thus serves as a primary source of RC. This interaction develops and leverages individuals' skills and knowledge (Fu, 2004). In BIM adoption, this can include both internal and external relationships. Internal relationships are those between workers, and workers and managers, or the internal hierarchy. External relationships are those between workers and clients, consultants, contractors, and any other entity external to the company (Lu & Sexton, 2009). Hence, BIM implementation is a social process involving interactions and networking. Jansen et al (2006) suggested that social relations between individuals and groups have been associated with the transfer of knowledge and learning, and focus on the pattern of the social network, the connectedness of a social unit, and its impact.

The development and use of RC are critical for small professional practices (Lu & Sexton, 2009). In the general management literature, it has been identified that RC plays a particular role in innovation (Hoegl et al, 2003). Clients and their networks, as well as the networks of the professionals, are important resources for professional practice (Lowendahl, 2000). Communities of practice, for instance, have been identified as important to the flow of knowledge within the knowledge-based organisation (Hildreth & Kimble, 2004). Furthermore, the choice of clients influence the development of the knowledge worker (HC), which in turn influences organisational structure (SC) (Tsai & Ghoshal, 1998).

As a result, RC can be defined as the network resources of a firm resulting from the interactions between the individual, organisation, and external supplier chain partners (Lu & Sexton, 2009). Lu & Sexton (2009) presented two elements in their framework that could be termed as BIM RCs when considering the BIM adoption process; these are the interaction environment and their RC. Their definition of an interaction environment emphasised the business environment where interaction takes place between the organisational team members and the competitive environment. While in the definition of RC, emphasis was given to the interactions between individual, organisational, and external supply chain partners, and included the reputation or image within the organisational hierarchy. The interaction environment and the organisational hierarchy are separated by a permeable organisational boundary; however, if RC represents the means to leverage HC, a BIM-enabled process already involves and recognises the interaction environment as an integral stakeholder and directly leverages the HC. The interaction environment in the BIM adoption process includes the IT vendors, government organisations and the academic community, among others. Therefore, BIM RC can be defined as the network capital of the firm that occurs in the interaction between the internal, external and environmental relationships. The internal relationships thus include those between workers, managers, and the internal hierarchy. The external relationships are between workers and clients, consultants, contractors, and any other entity external to the firm.

The BIM adoption process often requires a search for knowledge outside the firm's existing knowledge base, and frequently in areas that are not directly related to its primary design focus (Arayici et al, 2011a) . This is why RC, or the strength in which the firm relates to its internal hierarchy, external entities and environment, can be a critical source of new knowledge that feeds a firm's innovative capabilities (Costa et al, 2014). It thus seems appropriate to assume that the existence of links within the firm’s hierarchy, with other firms, the learning and regulatory institutions and other stakeholders will have a determining impact on the SME architectural firms’ innovative capability, and particularly on its BIM adoption process (Lu & Sexton, 2009). Hence, it can be assumed that firms with stronger ties to their supply chains and clients also gain increased sensitivity and improved practice, which could turn their BIM adoption into a more appropriately oriented and effective process. Because RC is seen as the creation and maintenance of enduring internal and external relationships, building and maintaining good relationships with clients has a significant influence on the application and acceptance of new ideas (Lu & Sexton, 2009) .

Although Reed et al (2006) suggested that HC is directly associated with performance, recent extensions of social capital theory (beyond its socioeconomic origins) have argued that the unique value of HC can be enhanced by, “*the good will that is engendered by the fabric of social relations and that can be mobilized to facilitate action*” as stated by Adler & Kwon (2002) (p,17). As a result, rich internal and external social connections that consist of high-status (competent and credible) participants and stakeholders from a diverse set of disciplines, can reduce the amount of time and investment required to gather information (Burt, 2001). Accordingly, these relationships can serve as valuable conduits for knowledge diffusion and transfer, and facilitate knowledge combinations, which can support ‘knowledge-creating organisations' (Nonaka & Takeuchi, 1996), and hence, develop a firm’s intellectual capital (Costa et al, 2014). Moreover, just as firms can have a HC advantage, the complex processes that evolve as a result of productive employee interactions can result in a human process advantage (Reed et al, 2006). As such, the combination of human and social capital has process implications that can also increase a firm’s financial performance. Similarly, Costa et al (2014) suggested that “HC (education, training, skills, etc.) will not yield in critical new resources unless it is combined with social networks”.

Thus, it can be assumed that higher levels of valuable social relationships should enhance the positive relationship between HC and performance. As such, RC’s productive potential lies primarily in its ability to leverage the productivity of human resources; this is a view supported by a wide range of HC-related phenomena, such as inter-unit resource exchange and innovation, entrepreneurship, new venture success, inter-firm learning, the creation of intellectual capital, and cross-functional team effectiveness (Costa et al, 2014). Similarly, if RC provides informational benefits (who you know affects what you know), it follows that the more informationally-rich a firm's internal and external ties, the more its employees will accomplish (e.g. absorb, learn, innovate). In turn, the more competent the employees (i.e. the higher their HC), the more they will value, assimilate, and apply knowledge from informationally enriched social ties (Cohen & Kaimenakis, 2007). This can set into motion a virtuous and dynamic cycle; namely, the more a firm’s HC is enhanced by social linkages, the more attractive employees become to additional informationally-enriched and high-status social ties, and so on. As such, it is anticipated that HC is positively associated with a firm's financial performance, but its positive association is enhanced or leveraged when combined with the firm's internal relationship capital and by the firm's external RC.

Based on the above discussion, the study proposed four classifications of RC to understand the extent to which they are proactively managed. These are as follows: RC exists among individuals and groups, which adds value to activities. Relationship knowledge is mostly tacit, composed of cultural norms that exist as a result of working together, and RC is reflected by an ability to collaborate effectively (Lu and Sexton, 2009). The classifications are thus;

1. The internal motivation and the network resource of a firm
2. The external motivation and the network resource of a firm
3. The environmental motivation and the network resource of a firm

4. The image and reputation and the network resource of a firm

3.3.2.1 INTERNAL RELATIONSHIP MOTIVATION AND THE NETWORK RESOURCE OF A FIRM

An internal relationship refers to the development and maintenance of the relationship between individuals within an SME architectural firm, including the production line workers, managers, supervisors, administrative staff, and facilities and maintenance support. BIM adoption and implementation requires these internal relationships in order for the firm to effectively deliver a project (Arayici et al, 2011a). Although this type of relationship may be informal in BIM adoption (Yamaguchi, 2013), it is a valuable resource for successful innovation (Arribas et al., 2013). Nahapiet & Ghoshal (1998) described this relationship as the sum of the actual and potential resources embedded within the firm, which is derived and made available through the network of relationships of the firm's social unit. Holzer (2015) emphasised this in the BIM adoption process suggesting that this potential resource is formed through the interaction between the top management, the IT manager and the employees. Elsetouhi et al (2015) further described internal RC as a result of the interaction, communication and collaboration among individual employees within a firm, and can be measured by their knowledge sharing and cultural experiences. Reche et al. (2008) emphasised that, through the internal setting of a firm, RC provides a conducive environment for employee flexibility in an uncertain environment. Oh et al. (2006) suggested that such a conducive environment can enable a social unit in a firm to be significantly responsive through innovation and recurrent patterns of dynamic relationships between its individuals. Hence, the internal relationship can be a measure of the innovation capability and network resource of a firm.

Among the approaches provided in the literature, that explore the ways in which internal relationships motivate innovations, such as BIM processes, is the implementation of rewards and punishment schemes as stimuli for successful knowledge sharing (Egbu & Botterill, 2001). Motivating employees to share the knowledge they have involves good people management, as trust is itself an incentive. The establishment of a psychological contract between employer and employee, for example, is a constructive approach to developing a knowledge-sharing culture (Scarbrough et al, 1999). Moreover, Subramaniam & Youndt (2005) demonstrated that this kind of relationship represents the informal interactions and information exchanges among employees that develops a smooth and desirable work atmosphere. Therefore, it is a result of the interaction and collaboration among employees within an organisation who share their knowledge and experiences. Nonaka et al (2008) emphasised that internal relationships provide an excellent atmosphere for increased employee flexibility in an uncertain environment. Groups can be more responsive, largely because of the recurrent pattern of dynamic relationships among people within the group. In this study, four indicators were identified and discussed as predictors for the internal relationship that could influence BBVC in SME architectural firms, and these are; communication flow, trust, participative culture, and uncertainty avoidance.

Since the main objectives of the BIM process in firms are to improve and ensure efficient communication and collaboration between stakeholders in the project (Holzer, 2015), the relevance of communication flow and its effect on the BBVC cannot be over-emphasised. Moreover, Jo & Shim (2005) suggested that effective employee communication has been shown to increase job satisfaction and employee performance; hence, it potentially results in organisational success and innovation. Furthermore, as most social interactions require some degree of trust, it is a mechanism that helps to deal with the unknown in complex situations, especially those where foreseeing the outcome is not possible due to numerous uncertainties (Grabner-Kräuter & Kaluscha, 2008). Eisenegger & Imhof (2008) described trust as the most significant operational resource in a social unit, highlighting that it strengthens existing relationships between individuals and at the same time acts as a magnet for future relations.

Clegg et al (2002) argued that SME architectural firms develop their motivation and capability to innovate easily when they establish positive expectations about an idea from individuals in their firm and this occurs when they have created a basis of mutual trust. Thus, the employees of a firm are more involved in innovation processes when they think their ideas are considered. This is particularly true as innovation infers risks, and it is implausible for firms to engage in innovation when trust does not exist between the individuals in the firm. Valenzuela & Contreras (2014) suggested that, in order to adjust to the dynamism of the technology marketplace, SME architectural firms seem to be flexible and timely in their decision making on innovation. However, this requires collaborative relationships between their employees and other partners to acquire the knowledge needed (Nooteboom, 2006). Hence, Valenzuela & Contreras (2014) further suggested that technological innovation in SME architectural firms is essentially described by their accrued knowledge and skills within which learning takes place. They argued that this is based, to some extent, on the trust built between the individuals in that context and their participating agents; hence, trust indirectly influences innovation through learning. Mollaoglu et al (2015) emphasised that building trust among employees is crucial to the success of any improved learning from the BIM process. However, they argue that there are some types of trust, such as the technical trust, that have a direct influence on innovation. Consequently, one can argue that the concept of trust is more dynamic than static, as it is not a product of a particular decision but rather a set of approaches regulated by attitude, behaviour, and even decision-making. In that sense, trust is an element of the business environment (Valenzuela & Contreras, 2014).

The concept of participative organisational culture has also been identified as significant for the BIM implementation process in that it involves and values collaboration and the exchange of input between the different stakeholders within and outside an SME architectural firm (Arayici et al, 2011a). Thus, teamwork is valued, and the emphasis is placed on the collective rather than the individual, meaning that the firm overall and its employees specifically share goals (Succar, 2009). A participative organisational culture values innovation and seeks input from employees and other stakeholder groups to ensure a thorough analysis of its decisions and policy (Caywood, 1997). Individuals within the firm hierarchy are often integrated or multifunctional, and emphasise open communication across different levels in the BIM process. Caywood (1997) also suggested that a participative organisational culture values information, seeks input from internal relationships, and functions as an open system with respect to its employees, their opinions, and their concerns. This allows for the efficient flow of information allowing employees and those at lower levels of the firm to have an input in management decision-making. When this input is sought and encouraged, a firm can reap a successful innovation process (Caywood, 1997). Accordingly, SME architectural firms with participative organisational cultures would make decisions in a decentralised manner across varying levels of the firm and enable implementation by those who hold responsibility for a particular task (Caywood (1997). As innovative ideas can come from any level of the firm, from the employee to top management, this would also mean ensuring increased teamwork and that value is placed on employees at all levels of a firm.

In addition, uncertainty avoidance is considered an indicator of an internal relationship, and based on the notion that some risks need to be faced when introducing and implementing new technologies or approaches, including, for example the BIM process (Bin Zakaria et al, 2013). Hofstede (2011) identified uncertainty avoidance as a cultural dimension of relationships that describes the degree to which employees prefer conservativeness in an established method and process over trying a new one; he argued that this is in order to reduce social anxiety. For example, in firms with high uncertainty avoidance, employees tend to prefer clear requirements and instructions, to follow organisational rules, to take fewer risks, and to demonstrate greater loyalty to the employer (Caywood, 1997). Such a context contradicts the notion that SME architectural firms usually develop their initial motivation and capability to adopt BIM through employees' championship of trial and risk (Succar, 2009). Mollaoglu et al (2015) suggests that high levels of uncertainty avoidance have an adverse impact on innovation. According to Caywood (1997), when SME architectural firms exhibit low uncertainty avoidance within their hierarchy, employees can feel more tolerant of ambiguous situations, develop less resistance to change, and show greater interest in taking risks, and this ultimately improves internal innovations within the internal relationship of the firm.

3.3.2.1.1 Hypotheses and Sub-Hypotheses: Internal Relationships

The following hypotheses are thus provided which is also illustrated in Figure 8;

$H4_1$: The motivation and network resources within the internal relationships of SME architectural firms have a significant correlation with BBVC.

$H4_0$: The motivation and network resources within the internal relationships of SME architectural firms have no significant correlation with BBVC.

Sub-hypotheses;

- *H6a: Firms that derive their motivation and network resource through the internal relationship characteristic of **effective communication flow** are likely to succeed in BBVC.*
- *H6b: Firms that derive their motivation and network resource through the internal relationship characteristic of **confidence and trust** are likely to succeed in BBVC.*
- *H6c: Firms that derive their motivation and network resource through the internal relationship characteristic of **participative culture** are likely to succeed in BBVC.*
- *H6d: Firms that derive their motivation and network resource through the internal relationship characteristic of **less uncertainty avoidance** are likely to succeed in BBVC.*

3.3.2.2 EXTERNAL MOTIVATION AND THE NETWORK RESOURCE OF FIRMS

The BIM adoption process is a form of innovation that cuts across internal and external boundaries (Lehtinen, 2011) and enables data exchange, sharing, and communication within these boundaries (Kiviniemi, 2011). This process can, therefore, question existing and established practice within and between participating firms and hence, force them to cooperate with each other culturally whenever the process is active. However, Bellamy & Taylor (1998) suggested that this kind of intra and inter-organisational cooperation implies the integration of information domains. Nevertheless, in the BIM adoption process, the integration of this information domain entails a sphere of influence that includes, legal issues, copyrights, intellectual property (IP), the ownership and control over information, specifications, formats, exploitation, and interpretation (Brown & Osborne, 2013). Bekkers (2013) suggested that, the integration of this domain to achieve this process evokes issues of interoperability, which includes; technical interoperability, semantic interoperability, cultural interoperability and legal interoperability (Gottschalk, 2009).

Technical interoperability refers to the compatibility of the required ICT infrastructure in enabling the smooth integration of the information domain (Brown & Osborne, 2013). Gallaher et al (2004) described this kind of interoperability as the ability of a firm and its stakeholders to manage and communicate electronic products and project data in an integrated business process system throughout a project lifecycle. These can include addressing software related issues (Codinhoto et al, 2013), ICT infrastructure which contains both software and hardware (Brown & Osborne, 2013) or even network issues (Succar, 2009). Codinhoto et al (2013) suggested that technical interoperability can affect the success of BIM adoption among stakeholders. Newton et al (2009) described the technical interoperability in a BIM adoption process as the reliability of the software application to enable effective data exchange between the firm and their different stakeholders in a BIM project lifecycle. Bernstein & Pittman (2004) emphasised the need for an established strategy in tools and software as a capability for successful BIM adoption, and argued for the ability of all participating stakeholders to access data and enable the transfer of information from one software to another since it is difficult to establish a model that works for every application. Hence, in this context, and as an indicator for RC, technical interoperability refers to the network resources and the capability of the SME architectural firm, which is developed through the ability of their external professional partners to sufficiently acquire the required ICT infrastructure that can enable effective communication and collaboration in a BIM adoption process.

As such, another issue of interoperability considered for this study is semantic interoperability, which Bekkers (2013) described as the idiosyncrasy of information specifications and the lack of standard data definitions. In the case of a BIM process, this issue is buttressed by Belsky et al (2016) who argued that, despite the efficacy of the popular Industry Foundation Classes' (IFC) exchange schema in significantly addressing data definitions within the BIM tools, there are still significant difficulties in externally exchanging information between stakeholders. They stated that the IFC exchange schema is too generic to capture the full semantic meaning needed for direct use in the BIM tools operated by the different stakeholders in the industry. Venugopal et al (2012) argued that, for BIM to be meaningful for data exchange, type-instance relations, aggregations, geometry, and topological relationships must be defined precisely. Hence, Belsky et al (2016) stated that, such insufficient semantic definitions of data exchange among stakeholders, can prevent firms achieving the full potential of the BIM through seamless interoperability.

According to Brown & Osborne (2013), cultural interoperability can be defined as the ability of a firm to overcome any conflicting organisational norms and values, communication patterns, and grown practices and habits that inhibit the effective integration of the information domain with other firms in an integrated environment. However, in the context of this study, cultural interoperability as an indicator of RC refers to SME architectural firms' network resources and capabilities developed through the ability of its external professional partners to overcome their subjective cultural differences in order to effectively communicate and collaborate within the BIM adoption process. Gallaher et al (2004) also added that cultural interoperability is the ability of the firms within an integrated system to manage, and share project data through a business process.

Another issue considered is legal interoperability, which Bekkers (2013) defined as the form of interoperability that deals with the different legal regimes with conflicting rights and obligations. This is relevant for BIM because, as Newton et al (2009) suggested, legal issues, responsivity, copyrights, and the potential loss of intellectual property when sharing BIM data significantly contributes to the slow adoption of BIM as a project platform for firms to seamlessly connect with their external partners. Newton et al (2009) suggested the need to redefine the workflow, roles, and responsibilities in the BIM-based process to overcome this issue. Hence, in this context, legal interoperability refers to the ability and network resources of SME architectural firms to seamlessly resolve any conflicting rights and obligations in their workflow while working in the BIM environment.

Thus, based on the above discussion, the study contextualises four indicators of interoperability that can predict the success of a BIM process; these are technical interoperability, semantic interoperability, cultural interoperability, and legal interoperability.

3.3.2.2.1 Hypotheses and Sub-Hypotheses: External Interoperability

From this discussion, the following hypotheses have been formulated and presented which is also illustrated in Figure 8;

$H5_1$:, The motivation and network resources of SME architectural firms, through external interoperability, have a significant correlation with BBVC.

$H5_0$:, The motivation and network resources of SME architectural firms, through external interoperability, have no significant correlation with BBVC.

Sub-Hypotheses:

- *H5a: Firms that derive their motivation and network resource as a result of their **technical ability** to interoperate with external partners are likely to succeed in BBVC.*
- *H5b: Firms that derive their motivation and network resource as a result of their **semantic ability** to interoperate with external partners are likely to succeed in BBVC.*
- *H5c: Firms that derive their motivation and network resource as a result of their **cultural ability** to interoperate with external partners are likely to succeed in BBVC.*
- *H5d: Firms that derive their motivation and network resource as a result of their **legal ability** to interoperate with external partners are likely to succeed in BBVC.*

3.3.2.3 ENVIRONMENTAL MOTIVATION AND NETWORK RESOURCE OF FIRM

The idea of an environmental relationship as a component of RC is informed by the assertion of Lu & Sexton (2009) who described the interaction environment as an integral aspect affecting innovation success in SME architectural firms within the construction industry. The claim is also supported by Zahra (1996) and Prajogo (2006) who suggested that the capability of the firm to perform innovation activities can be influenced by their relationship with the external environment. Ting et al (2012) also claimed that the environmental concerns have a substantial effect on a firm's innovation strategy. Hence, it is reasonable to consider the environmental relationship as a component of RC, and can thus be used to investigate the BIM adoption process.

According to Lu & Sexton (2009), the environmental relationship can refer to the network resources of the firm that result from interactions with the business environment. This interaction affects the innovation capability of the firm (Ting et al, 2012). Lu & Sexton (2009) suggested that this environment can be based on two aspects, which are 'the task environment' where the client's interaction occurs, and 'the competitive environment', where the firm competes with other firms on customers and scarce resources. However, Bourgeois (1980) suggests that the task environment can include the interactive relationship resulting from customers, technology, the market place, competitors for both markets and resources, and regulatory groups, such as government agencies, unions, and interim associations. Bourgeois (1980) classified the environmental relationship as based on three focuses; the first focus is on entities external to the firm including the customers, suppliers, competition and regulatory groups; the second focus is on the attributes brought by external market forces, such as complexity, dynamism and munificence. The third focus is on the managerial perceptions regarding the attributes of the external forces. All the above definitions possess a commonality in stressing that the environmental relationship fundamentally relates to four distinct but complementary elements; these are the client related interactions, the competitive environment, the technology market place and the regulatory groups.

Hence, in contextualizing the elements mentioned above, this study considered four indicators to form the predictors of determining the network resource and capability of RC that can be used to investigate the relationship effect on BIM adoption success. These indicators are the; client system as public sector, client system as private sector, competitive environment, technology market dynamism, and regulatory groups. Under this concept, Ting et al (2012) described dynamism as the rate of change for innovation in the market, which they considered similar in concept to environmental turbulence or a high-velocity environment. This degree of turbulence can also stimulate innovation through increasing the awareness of new ideas in the environment (Rothenberg & Zyglidopoulos, 2007).

With regard to the client system, the concept of the client driving innovation is well established in the literature (Tether & Tajar, 2008), and particularly in that of the construction industry (Sexton & Barrett, 2004; Kiviniemi, 2006; Brandon & Lu, 2009; Kiviniemi, 2011; Jaradat et al, 2013). This is because the needs and requirements of clients inform most of the valuable information (Tether & Hipp, 2002) that encourage firms to adopt new practices (Guler et al, 2002). Brandon & Lu (2009) argued that this is because clients have significant impacts, both in relation to their projects and their drivers, on policy reform, and this changes the way in which others work. Hence, the government, as a major client, usually takes responsibility to use its influence to drive this to positive effect. This is even true in the BIM adoption process, where governments are the major drivers for most successful BIM adoption initiatives in most countries (Wong et al, 2009). Wong et al (2009) provided evidence of the positive role played by both the public and private sectors as major stakeholders in promoting and providing for BIM adoption in Finland, Norway, Singapore and Denmark. The UK mandate for BIM adoption in 2016 is a current case in point with regard to governments' impacts as clients driving innovation in the construction industry. Hence, it is useful to consider the relationship between clients' interactions with the innovation environment of SME architectural firms, and BIM success in the Nigerian sector.

With regard to regulatory groups, the idea of these groups driving innovation has been argued in literature. While this is evident in the case of the UK, where regulation is seen as an enabler to the widespread industry adoption of BIM (Succar & Kassem, 2015), a study on BIM acceptance in South Korea (Lee et al (2013) shows otherwise, suggesting that pressure by regulation can negatively impact willingness and thereby affect sustainability. Furthermore, Toole (1998) suggested that regulations, such as building codes, contributed to the conservativeness of the building industry in the 1990s. However, this assertion can now be challenged following the change in the regulatory position, as seen in the UK's 2016 mandate. Therefore, it is reasonable to consider regulatory groups as a potential indicator of BIM innovation in SME architectural firms.

3.3.2.3.1 Hypotheses and Sub-Hypotheses: Environmental Relationships

The study proposes the following hypotheses for investigation which is also illustrated in Figure 8.

$H6_1$: The motivation and network resources of SME architectural firms, through environmental relationships, have a significant correlation with BBVC.

$H6_0$: The motivation and network resources of SME architectural firms, through environmental relationships, have no significant correlation with BBVC.

Sub-Hypotheses;

- *H8a: Firms that derive their capability and network resource through motivation from **the client system** in the innovative environment are likely to succeed in BBVC.*
- *H8b: Firms that derive their capability and network resource through motivation from **technology market dynamism** in the innovative environment are likely to succeed in BBVC.*
- *H8c: Firms that derive their capability and network resource through motivation from **competitiveness** in the innovative environment are likely to succeed in BBVC.*
- *H8c: Firms that derive their capability and network resource through motivation from **government and regulatory systems** in the innovative environment are likely to succeed in BBVC.*

3.3.2.4 IMAGE AND REPUTATION AS A MOTIVATION AND NETWORK RESOURCE FOR FIRMS

The value of RC is determined by a firm's image and reputation, and it includes network, brand, and customer capital (Karchegani et al, 2013) . Ou & Hsu (2013) described image and reputation as valuable assets that a firm’s management can use to increase their innovation capability and competitive advantage (Bergh et al, 2010). A greater measure of image and reputation is perceived though intangible resources, which are capable of providing a basis for sustainable competitive advantage due to their valuable and hard to imitate characteristics (Roberts & Dowling, 2002). Ou & Hsu (2013) therefore defined image and reputation as the emotional reaction of external partners and stakeholders of a firm. Reputation refers to the emotional reaction of external stakeholders to a firm as well as the knowledge they hold about the firm's competitive advantage. Roberts & Dowling (2002) elaborated on these definitions to indicate that reputation demonstrates itself as the degree to which the firm is seen as good. Thus, reputation includes not only carries perceptions about past actions, but also about the future prospects of a firm (Rindova et al, 2010) .

Accordingly, in this context, image and reputation can be defined as the ability of a BIM innovation to meet its stakeholders' expectation (Luoma-aho, 2007). Its success is measured by the extent to which the innovating firm satisfies and renders itself to the stakeholder (Luoma-aho, 2007). Expectations will also be formed without communication and public relations, but with strategic thinking and planning; expectations can thus be applied to fortify a reputation. A good reputation of a given innovation, such as BIM, is derived from the ability of a firm to manage impressions, build strong relations with key stakeholders, and manage any criticism targeted at the innovation (Luoma-aho, 2007). An example is when stakeholders in the industry first hear of BIM innovation and form their initial impressions of its efficacy. Alongside available information, these initial impressions form the basic level of trust in the BIM innovation. (Luoma-aho, 2007) argues that such trust could be transmittable, and may be 'loaned' from other similar innovations. This first initial trust, or total lack of trust, creates expectations. Based on further information and experiences, whether mediated or personal, the trust step by step turns into reputation (Luoma-aho, 2007).

Moreover, there is evidence to indicate that SME architectural firms' approaches to image differ from that of larger firms as a result of their difference in size and resource. However, they also maintain that image is key to their reputation, and vice versa (Abimbola & Kocak, 2007). They are more integrative in the way they build their image and reputation compared with large organisations where such efforts may be shared among different teams within and outside the firm. However, Abimbola & Kocak (2007) studied the distinction in terms of the quantitative and operational definitions of image and reputation among different size firms and suggested a blurred practice in SME architectural firms. They argued that, although SME architectural firms have a reputation strategy, this is not a formal, explicit process as is the practice in larger firms. This is plausible as such activities are usually undertaken by entrepreneurs or limited teams within the SME architectural firms (Bell et al, 2004).

Furthermore, Laforet (2010) suggested that, even although the SME architectural firms do not brand themselves or their images in the same way or use the same marketing techniques as large companies, reputation remains critically important. Laforet (2010) argued that reputation is a key asset for any firm regardless of size and can be responsible for attracting or discouraging customers, employees and external partners. Simpson et al (2006) suggested that satisfying customers, improving company image, and enhancing reputation and employee satisfaction are the positive outcomes of innovation that consequently influence the long-term benefits of innovation.

The Schaarschmidt (2016) study on frontline employees' participation in service innovation implementation and perceived external reputation provided a measure by which to classify the determinant of reputation from the firm's perspective. Given the context, the BIM adoption process in SME architectural firms is treated as a service innovation where firms depend on their ability, not only to develop new services to gain competitive advantage (Schaarschmidt, 2016), but also to pragmatically implement these service innovations into daily practice (Chimhanzi & Morgan, 2005; Somech & Drach-Zahavy, 2013). Enz (2012) described service innovation as the introduction of new ideas that are service-centred and provide alternative ways of delivering a benefit. This is particularly true for BIM, and introduces new ways of doing services in the industry to improve efficiency and productivity (Arayici et al, 2011b) . Furthermore, Enz (2012) described the process as acquiring new service business models through continuous operational improvements, technology, investment in employee performances, or the management of customer experiences. Schaarschmidt (2016) suggested that HC is key in this process. Similarly, Melton & Hartline (2010) advocated that a client's acceptance or rejection of new innovative services, such as BIM, is dependent on employees' motivations to support or impede their firm's strategic initiatives by either recommending new services to, or hiding them from, the clients (Cadwallader et al, 2009; Schaarschmidt, 2016).

Schaarschmidt (2016) defined expectancy theory as the link between reputation and service innovation in the firm. The theory states that people act by expected outcomes (Vroom, 1964). Furthermore, the theory states their belief determines the choice of people, persistence, and performance in how well they will execute a certain activity (Wigfield & Eccles, 2000). Thus, the more one holds a belief in being able to perform a task successfully, the more excited and happy one will be to approach the task (Schaarschmidt, 2016). Nonetheless, Yuan

& Woodman (2010) further categorised the motivation to display innovative work behaviour in an efficiency-oriented and socially-oriented perspective. However, Gligorijevic & Leong (2011) described the efficiency-oriented and the socially-oriented nature of this as the functional and social dimensions respectively.

Accordingly, the theory provides three dimensions of reputation, which are the basis for developing the indicators for this component of RC, and these are;

- Functionality dimension (outcome of BIM quality)
- Social dimension (reputational gains)
- Internal dimensions (employee’s perception)

Miller (2012) stated that David Miller Architects is a motivating case that underpins the above discourse. He argued that, while some of the growth in SME architectural firms during the BIM adoption years were to be attributed to a young growing office, he believes the quality and quantity of the output due to BIM has had a contribution, particularly when considering their repeat clients that represent the majority of their workload.

The functionality dimension of reputation, which is based on the efficiency-oriented perspective, assumes that innovation, and particularly BIM, serves a key function in improving productivity and efficiency (Arayici et al, 2011b) and that investment decisions are driven by expected positive performance outcomes (Schaarschmidt, 2016). Yuan & Woodman (2010) suggested that expected performance outcomes are positive when employees believe that their innovative behaviours will bring performance improvements or efficiency gains for their work roles or work units. An employee's level of subjective dimension (an employee’s external perception) influences how outsiders evaluate the firm, which occurs predominantly along the reputation dimension, such as being a good employer, being client oriented, being socially responsible, and providing innovative products and services (Schaarschmidt, 2016). Schaarschmidt (2016) presented evidence of a positive relationship between this kind of reputation and the firm’s performance, from which an employee might benefit as a result of the association. Thus, one's impression of working for a reputable, innovative company raises one's expectations concerning the firm's future (innovation) performance (Schaarschmidt, 2016).

On the other hand, the social dimension provides a different approach to explaining the rationale for people's engagement with a service innovation, which suggests a possible relationship with BBVC. Schaarschmidt (2016) argued that employees may exert self-protective or self-confident impressions in management. While the former resonates with approaches to support the established social image and possibly narrow employees' range of innovative behaviours, the latter establishes tactics for purposely improving the current social image (Liu et al, 2014; Bourdage et al, 2015). Hence, the study postulates that employee's expected gains in personal social image or reputation will explain their innovative behaviours, such as recommending new services to customers (Schaarschmidt, 2016) which could subsequently affect BIM business value in the firm. This is particularly true in the case of the BIM adoption process in SME architectural firms where the individual championship of employees plays a role in determining the level of implementation of BIM in that firm (Kori & Kiviniemi, 2015). Schaarschmidt (2016) further argued that employees who submit new ideas like BIM in a work context might be driven by a motivation to display their creativity, competence, and talent to supervisors and top management or co-workers.

Accordingly, this study adopts the notion that expected reputational gains, the outcome quality of BIM, and the employee's external perception as elements in, and predictors of, innovative work. Additionally, the employee's attitude toward newness in general, and to supervisors, top management and co-workers, might increase their social standing as being innovative (Schaarschmidt, 2016). Subsequently, this can be applied to the service innovation context of the BIM adoption process.

3.3.2.4.1 Hypotheses and Sub-Hypotheses: Reputation and Image

Based on the above discussion, the study formulates the following hypotheses which is also illustrated in Figure 8:

$H7_1$: The motivation and network resources, through the reputation and image of SME architectural firms, have a significant correlation with BBVC.

$H7_0$: The motivation and network resources, through the reputation and image of SME architectural firms, have no significant correlation with BBVC.

Sub-Hypotheses:

- *H7a: Firms that derive their motivation and network resource as a result of the* ***functional reputation*** *of the use of technology are likely to succeed in BBVC.*
- *H7b: Firms that derive their motivation and network resource as a result of the* ***social reputation*** *of the use of technology are likely to succeed in BBVC.*
- *H7c: Firms that derive their motivation and network resource as a result of* ***employees' subjective reputation*** *concerning the use of technology are likely to succeed in BBVC.*

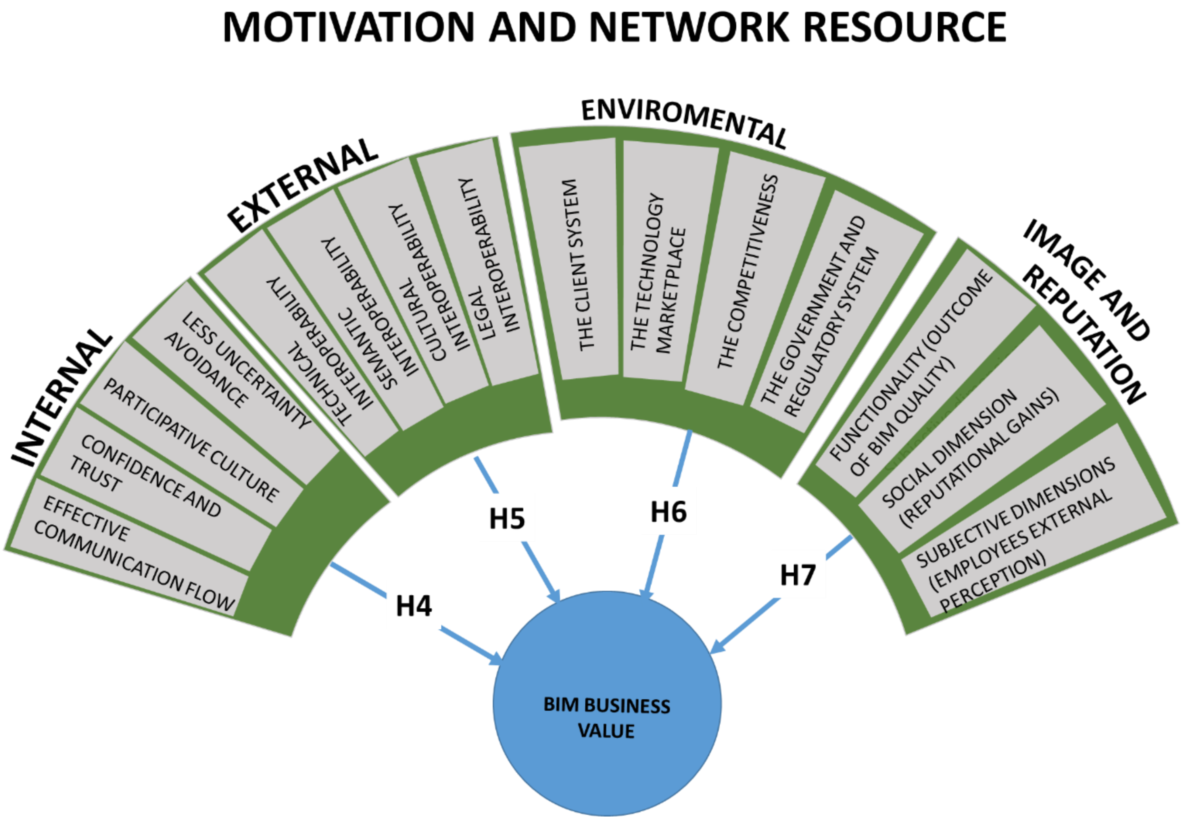

Figure 8: A model for RC components of BIM adoption in SME architectural firms

3.3.3 STRUCTURE CAPITAL (SC)

Building on the definition by Lu & Sexton (2009), SC is described as the built-in capital of organisational systems, processes and schemes, tools, rules and routines. SC can therefore be defined as everything that is owned by the firm that is not the human or RC but serving the purpose of both when the routine of work is active. It is primarily explicit and rule-based and can exist independent of the human resources of the firm. Aramburu et al (2013) described it as the capital demonstrating all of the value that is left behind in the organisation when the employees have left the workplace. Karchegani et al (2013) suggested it could include codified knowledge, procedures, processes, goodwill, patents, and culture. SC is also described as the organisational competencies of the firm comprising the routines, procedures, processes, systems, culture, databases, structures and intellectual property (Karchegani et al, 2013). They further argued that it is an intangible asset that is formed to allow the HC and the RC to develop. However, due to the explicit organisational nature of its function, SC has been called numerous names. For example, due to its process-centred function, Namvar et al (2012) called it process capital. They suggest that it is formed as a result of investments, processes, structures and activities established by organisations and aimed at changing or maintaining HC or influencing relational capital. Meanwhile, Egbu (2004) called it organisational capital since it represents the knowledge in processes, systems, and structures, as well as behaviours, norms, mental maps, core competencies and culture, and thus influences outputs in the organisation. Chen et al (2004) called it innovation capital because of its explicit service as a powerhouse to intellectual property, such as patents, copyrights and trademarks as well as other intangible assets, such as the talents and theory by which an organisation is run. Karchegani et al (2013) suggested that an effective SC is that which provides a supportive environment for effective knowledge sharing, collective knowledge development and more productive human resources. Ngah & Ibrahim (2011) suggested that, as a system for coding, storing, transmitting and sharing knowledge, SC can be described as the knowledge embedded in the non-human storehouses and routines of the organisation. In addition, Lu & Sexton (2009) stated that it consists of the organisation's mechanisms and structures, such as patents, concepts, models, computers and administrative systems as well as organisational culture, and these can help support employees in a quest for optimum performance

Edvinsson & Malone (1997) highlighted the importance of SC in innovation suggesting it is an integral part of the innovative capacity of firms. Furthermore, the importance of SC as an integral part of the BIM adoption process is emphasised by numerous studies (Newton et al, 2009; Codinhoto et al, 2013; Succar & Kassem, 2015). Given this context, some of the common themes arising in these definitions include processes, systems, structures, routines, procedures, processes, systems, culture, databases, structures and intellectual property, schemes, tools, rules and patents, concepts, models, computer, administrative systems, supportive environment, copyrights and trademarks. Although most of these terms are similar in meaning and importance, they are not all relevant to the BIM adoption process or to the context of the study. Therefore, the study adopts some of the major classifications of this item from the literature (Egbu, 2004; Lu & Sexton, 2009; Succar, 2009) and, where relevant, some of the items are used as indicators for the major classes (Aramburu et al, 2013). Consequently, three classes were identified and form the components of the source capital for this study; these are;

- The capability and support of the firm's systems and routines
- The capability and support of the firm's infrastructure and facilities
- The capability and support of the firm's process and schemes.

3.3.3.1 THE CAPABILITY AND SUPPORT BY FIRM SYSTEM STRCTURE

The importance of the capability and support of a firm's system and structure in fostering innovation has well been documented in the literature (Damanpour & Gopalakrishnan, 2001; Lu & Sexton, 2009; Aramburu et al, 2013), and explicitly recorded in the realisation of BBVC (Vass, 2015). This component refers to the type of administrative systems in place within a firm, the specific units of a firm and work teams that make up this system, the communication channels (both vertical and horizontal) that link the aforementioned units and teams, and the physical design of the workplace (Aramburu et al, 2013). Aramburu et al (2013) suggested four elements with regard to the organisation capital, which provide a basis for developing a viable indicator that could define this component. These are; administrative systems, policies and guidelines, and culture and strategies. In the same study, they also argue that the type of administrative system and the effectiveness of communication channels are critical to innovation capability. Given the context of this study and considering the holistic coverage of the four Intellectual Capitals, it is necessary to identify and avoid the overlapping of some indicators. Hence, this study identified four indicators in the capability and support of a firm's systems and routines when predicting the business value of BIM. These are discussed below.

Lu & Sexton (2009) explicitly suggested that the administrative system is a critical variable that defines successful innovation in SME architectural firms in the construction industry. Aramburu et al (2013) highlighted that certain types of administrative system facilitate knowledge sharing and knowledge creation processes more than others and are more learning-supportive. In particular, Nonaka & Toyama (2003) suggested that a system of flexible and informal organisation and management that is combined with a hierarchy structure conducive for the fostering of knowledge creation is better than rigid bureaucracy.

Furthermore, Aramburu et al (2013) stated that an effective communication channel can play a significant role in developing effective knowledge sharing and subsequent knowledge creation. Kalla (2005) described an effective knowledge management system as the function of integrated internal communications. This is particularly true in the case of a BIM process, which mainly relies on value creation through effective communication and collaboration (Arayici et al, 2011b). Aramburu et al (2013) argued that, although traditional knowledge flows were largely vertical, from the top management to the employees, supervisor to supervisee, in order to ensure effective knowledge management systems, firms need to also encourage horizontal knowledge flow to create innovation in their business value. Hence, an effective knowledge sharing system can be regarded as a catalyst for competitive advantage. Thus, Aramburu et al (2013) explicitly suggested that administrative systems and knowledge management systems play a critical role in the innovation capability of firms.

With regard to flexible policy systems for innovation, Succar (2009) explicitly highlighted the positive impact of clear and supportive policies and guidelines in enabling a smooth BIM adoption process. For example, Aramburu et al (2013) suggested that some firms deploy and adopt innovative professional policies and record positive impacts on their innovation capabilities.

In terms of allowing an experimentation culture, Aramburu et al (2013) suggested that the link between innovation, supportive cultures and knowledge sharing is critical, and argued that an experimentation culture allows for the continuous questioning of established patterns and for new idea generation and testing. Friedman et al (2001) suggested that the implementation of a system that accommodates experimentation culture can lead to an improvement in a firm's cultural values for innovation, such as increased trust and transparency, open mentality, mistakes considered as learning opportunities, support for experimentation and the exploration of new territories, and cooperation and mutual help.

3.3.3.1.1 Hypotheses and Sub-Hypotheses: System Structure

Considering the above discussion within the context of this study, the following hypotheses are formulated which is also illustrated in Figure 9.

$H8_0$: The capability and support of SME architectural firms through system structure have a significant correlation with BBVC.

$H8_1$: The capability and support of SME architectural firms through system structure have no significant correlation with BBVC.

Sub-Hypotheses:

- *H8a: Firms that develop their capability and support through* ***flexible administrative system for innovation*** *are likely to succeed in BBVC.*
- *H8b: Firms that develop their capability and support through* ***effective knowledge management systems*** *are likely to succeed in BBVC.*
- *H8c: Firms that develop their capability and support through* ***flexible policy systems for innovation*** *are likely to succeed in BBVC.*
- *H8d: Firms that develop their capability and support through* ***systems for experimentation culture*** *are likely to succeed in BBVC.*

3.3.3.2 THE CAPABILITY AND SUPPORT BY FIRM INFRASTRUCTURE

The relationship between the capability and support of an SME architectural firm's infrastructure and their facility and successful innovation within the construction industry is explicitly highlighted by Lu & Sexton (2009) and particularly linked with the BIM adoption process (Succar, 2009). Aramburu et al (2013) suggested that the efficacy of this component in enhancing innovation and knowledge sharing is particularly popular amongst information system studies. Aramburu et al (2013) also suggested that the availability of specific technological tools that foster the capture and storing of knowledge, as well as the connection between individuals, are relevant aspects of this component when considering the innovation capacity of firms. Succar (2009) stated that numerous indicators of this component form a requirement for BIM maturity in firms, and these are; software facilities, hardware facilities, network facilities, work environmental infrastructure, and upgrade and maintenance facilities. Aramburu et al (2013) highlighted the importance of this component for the improvement of knowledge sharing and innovation capabilities within a firm suggesting that the most important factor shaping the quality of knowledge lies in the quality of the workplace that supports innovation. Given these definitions, the study adopts all five indicators mentioned, which are the availability of; software facilities, hardware facilities, network facilities, a conducive working environment and maintenance and upgrade facilities.

Succar (2009) describes software facilities as the ability of the firm to avail itself with all the required applications, deliverables and data. Similarly, in the case of hardware facilities, it involves equipment, computers and deliverables. Network facilities involve networking solution deliverables, security/access control systems, and internet and intranet facilities, that the firm uses to improve its knowledge resources and create competitive advantage. Aramburu et al (2013) described the availability of a conducive work environment as the intangible area for knowledge management and emphasised that its availability and quality in a firm can enhance the innovation process. However, Succar (2009) simply referred to such infrastructure as any physical environment that supports knowledge-related sharing activities. Succar (2009) described the ongoing maintenance and upgrade of all infrastructural facilities as a suitable way to reap the BBVC in a firm. Building from the literature of exploitative innovation, (Lichtenthaler & Lichtenthaler, 2009; Lu & Sexton, 2009) explicitly highlighted the importance of sustaining the elements of intellectual capital over a period.

3.3.3.2.1 Hypotheses and Sub-Hypotheses: Infrastructure Facilities

Given the above discussion, the study formulates the following hypotheses which are also illustrated in Figure 9;

H9$_0$: The capability and support of SME architectural firms' organisational infrastructure and facilities have a significant correlation with BBVC success.

H9$_1$: The capability and support of SME architectural firms' organisational infrastructure and facilities have no significant correlation with BBVC success.

Sub-Hypotheses:

- *H6a: Firms that develop their capability and support through the **availability of hardware facilities** are likely to succeed in BBVC.*
- *H6a: Firms that develop their capability and support through the **availability of software facilities** are likely to succeed in BBVC.*
- *H6a: Firms that develop their capability and support through the **availability of network facilities** are likely to succeed in BBVC.*

- *H6a: Firms that develop their capability and support through the* ***availability of specific office space for ICT units*** *are likely to succeed in BBVC.*
- *H6a: Firms that develop their capability and support through the* ***availability of maintenance and upgrade facilities for technology*** *are likely to succeed in BBVC.*

3.3.3.3 THE CAPABILITY AND SUPPORT BY FIRM PROCESS

Lu & Sexton (2009) highlighted the importance of a reward and incentive scheme as an effective means of promoting ideas' generation among employees and increasing the innovative capability of firms. Succar (2009) suggested that training can also play a significant role in the preparatory stages of a firm's BIM adoption process. Lu & Sexton (2009) emphasised the internal training scheme as the most effective means to leverage both human and RC, using the support of the SC.

With regard to strategic innovation management schemes, Ichijo (2007) described these as a series of guideline principles that a firm can adopt in order to indicate to an organisation's members which areas of knowledge creation or innovation should be pursued. Aramburu et al (2013) highlighted that firms who have such strategic management schemes are able to facilitate their innovation capabilities and have a better competitive advantage in creating business value. Dorrego et al (2013) suggested that firms who clearly established such schemes and shared innovation strategies recorded an increased effectiveness in their process for generating new ideas process, and their innovation project management. This is also true in the BIM process; Succar (2009) confirmed that firms with a BIM implementation strategy reap the benefits of BBVC, which can help them sustain their knowledge resource through a long-term competitive advantage.

Moreover, Aramburu et al (2013) suggested that, among the characteristics of firms that establish this type of system and record a substantive competitive advantage in their innovativeness, a specific organisational unit, or group of qualified people, exist devoted to facilitating the generation and implementation of new ideas. The existence of such a unit gives a formal impulse to the generation of a specific cycle for innovation. Nonaka & Takeuchi (1996) described this cycle for innovation as a physical or virtual space where knowledge sharing and knowledge creation takes place.

3.3.3.3.1 Hypotheses and Sub-Hypotheses: Process and Schemes

Placing the above discussion within the context of this study, the following hypotheses were formulated which is also illustrated in Figure 9;

$H10_0$: The capability and support of organisational process and schemes of SME architectural firms have a significant correlation with BBVC.

$H10_1$: The capability and support of organisational process and schemes of SME architectural firms have no significant correlation with BBVC.

Sub-Hypothesis;

- *H6a: Firms that develop their capability and support through* ***reward and incentive schemes for innovation*** *are likely to succeed in BBVC.*
- *H6a: Firms that develop their capability and support through* ***in-house training schemes for innovation*** *are likely to succeed in BBVC.*
- *H6a: Firms that develop their capability and support through* ***strategic innovation management schemes*** *are likely to succeed in BBVC.*
- *H6a: Firms that develop their capability and support through* ***research and development schemes*** *are likely to succeed in BBVC.*

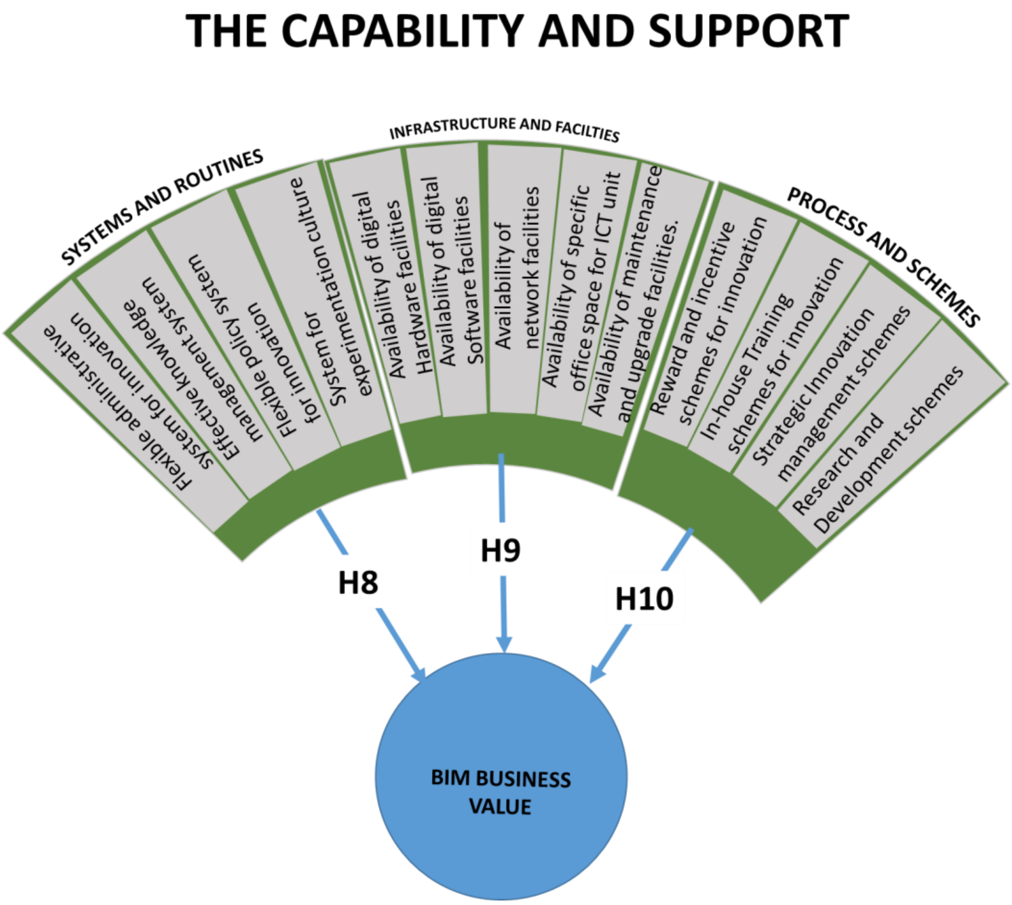

Figure 9: A model for SC components of BIM adoption in SME architectural firms

3.3.4 KNOWLEDGE CAPITAL (KC)

Lu & Sexton (2009) defined KC as the dynamic synthesis of both the context and process of knowledge creation and conversions between individuals within and outside SME architectural firms; they confirmed that such content is formed through the integration of the HC, RC and SC of a firm. Laperche & Liu (2013) defined KC as the set of scientific and technical knowledge and information that is produced, acquired, combined and systematised by one or several firms for productive purposes. Hence, Knowledge Capital can refer to the accumulated knowledge of one or several linked SME architectural firms, which is developed by the information flows of production and the value creation process of the firm. This production and value creation process turns knowledge into capital (Laperche & Liu, 2013) and ultimately can create BBVC (Vass, 2015).

Lu & Sexton (2009) demonstrated the relationship between KC and innovation through two dimensions, namely the explorative and exploitative approaches to innovation amongst small professional service firms in the construction industry. They suggested that firms are often involved in the exploratory dimension when exhibiting a project-specific nature of activities. This involves heavy reliance on the capacity, ability and motivation of staff at an operational level to solve client problems and generate a short-term competitive advantage. The outcome of this approach focuses on the effective and efficient delivery of services to satisfy the prevailing fee-earning project needs. In contrast, the exploitative approach mainly involves the capability, ability and motivation of senior management at a social level to improve the firm's effectiveness and efficiency in generating a sustainable competitive advantage. The focus on the latter approach is mostly based on internal organisation and general client development activities. Hence, the main difference between the two is that, in the explorative approach, the outcome is often not embedded in the organisational SC due to scarce management attention and the focus of the firms' resources on other current or near future project-specific demands. In contrast, in the later, newer phenomena, systems or structures are securely embedded in the SC of the firm.

Therefore, for a KC to be sustainable, some studys call for a reconciliation of the two dimensions and to combine them through integration (Argote et al, 2003; Bogner & Bansal, 2007). Subsequently, Lichtenthaler & Lichtenthaler (2009) introduced a third dimension to the context, called retention, which is defined as the capacity, ability and motivation of the firm to capture the outcome of both the exploratory and exploitative approaches, and to retain it over time for future use. However, Lichtenthaler & Lichtenthaler (2009) view of KC and its relationship with innovation came from knowledge management and dynamic capabilities research. They argued that KC is the resource capacity of a firm in forming the accumulated skills and expertise, as well as the facts that may be codified from the innovation process.

Given the context of this study, Lichtenthaler & Lichtenthaler (2009) view was adopted; hence, there are three dimensions to KC, which are the measure of the knowledge resource capacity of firms. These three dimensions of KC were identified as follows for the study.

1. Knowledge exploration capacity
2. Knowledge retention capacity
3. Knowledge exploitation capacity.

Nonetheless, in order for each of the above dimensions to create business value, studys emphasised the need to organise them into boundaries within and outside of the firm (Grant

& Baden-Fuller, 2004; Bogner & Bansal, 2007; Lichtenthaler & Lichtenthaler, 2009). Furthermore, Lichtenthaler & Lichtenthaler (2009) identified six elements, as shown in Table 2.

Table 2: A framework for knowledge resource capacity

(Source: Lichtenthaler and Lichtenthaler, 2009, page 1318)

	Knowledge Exploration	Knowledge Retention	Knowledge Exploitation
Internal (Intra-firm)	Inventive Capacity	Transformative Capacity	Innovative capacity
External (Inter-firm)	Absorptive capacity	Connective Capacity	Desorptive Capacity

Nevertheless, Su et al (2009) emphasised that, within the external boundaries, University and Research Institutes (URIs) have been playing a distinctive role in the innovativeness of firms, particularly with regard to knowledge-based innovation. They argued that specific partnerships with URIs amplify the exploration and retention of innovative ideas. This view is echoed by Simao et al (2016) who suggest that partnership for knowledge exploration and retention with URIs is important for SME architectural firms, particularly as they can lack competent staff who are dedicated to research and development, and capable of creating innovation as a business value for competitive advantage. Similar to Simao et al (2016), (Lane et al, 2006), study adopted two classifications for external boundaries that exist under the knowledge exploratory and knowledge retention dimensions, and these were the business, and the URI networks. Therefore, building on these previous studies, this study identified eight indicators to define the knowledge resource capacity of SME architectural firms for successful innovation.

Table 3: A framework for KC resource capacity

	Knowledge Exploration Capacity	Knowledge Retention Capacity	Knowledge Exploitation Capacity
Internal (Intra-firm)	Inventive Capacity	Transformative Capacity	Internal Exploitative capacity
External Business Network	Business Network Absorptive capacity	Business Network Connective Capacity	External Exploitative Capacity
External URIs	URIs Network	URIs Network	-

Network	Absorptive capacity	Connective Capacity	

Table 3 shows a framework for the KC resource capacity through a knowledge development direction from knowledge exploration capacity, through the knowledge retention capacity to knowledge exploitation capacity as suggested by Su et al (2009) that the knowledge exploration capacity is classified into three indicators; firstly, the inventive capacity refers to the ability of the firm to acquire knowledge originating from within the firm either through research or invention (Smith et al, 2005). Secondly, the business network's absorptive capacity refers to the firm's "ability to acquire knowledge through external business partners and environment" (Simao et al, 2016). Thirdly, the URI network refers to the ability of a firm to acquire knowledge through Universities, Research and Institutes (URIs) (Su et al, 2009). Lichtenthaler & Lichtenthaler (2009) suggested that this knowledge exploration capacity involves internally or externally generating new ideas and selections through choosing, by evaluation, the most appropriate concepts.

The knowledge retention capacity is equally classified into three indicators, and these are; firstly, the transformative capacity, which refers to the ability of the firm to maintain knowledge over time (Lichtenthaler & Lichtenthaler, 2009). Secondly, is the business network connective capacity, which refers to the ability of the firm's inter-organisational relationships and alliances with business partners to maintain knowledge over time. Finally, the URI network's connective capacity refers to the ability of the firm's relationships and alliances with URIs to maintain knowledge over time (Lichtenthaler & Lichtenthaler, 2009; Su et al, 2009).

Meanwhile, the knowledge exploitation capacity involves two indicators; the first is the internal exploitation capacity, which refers to the ability of the firm to apply existing knowledge to improve internal processes and productions with a view to creating competitive advantage (Lichtenthaler & Lichtenthaler, 2009; Lu & Sexton, 2009). The second is the external knowledge exploitation capacity, which refers to the ability of the firm to transfer the knowledge outwards through product delivery or alliances (Lichtenthaler & Lichtenthaler, 2009). Lichtenthaler & Lichtenthaler (2009) suggested that the knowledge exploitation capacity involves the reproduction of new approaches in diverse contexts, and their internal and external applications in different settings. However, he argued that the knowledge retention capacity is what connects the processes of both exploration and exploitation, and ensures integral knowledge transfer, which ultimately yields a new competitive advantage process. Following this discussion, the next section will discuss the three capacity dimensions.

3.3.4.1 THE KNOWLEDGE EXPLORATION CAPACITY

Lu & Sexton (2006) described the knowledge exploration capacity of a firm as the ability to create and use new resources and capabilities to increase organisational value and thus generate a sustainable competitive advantage. As stated, this dimension plays a role in the part of KC that involves outsourcing resources and capabilities, and these are divided into three indicators; the inventive, the business network absorptive, and the URI's network absorptive capacity. Since the main objective of this section is to explain the link between this indicator and how they could create BBVC, in order to postulate a hypothesis, the inventive capacity is discussed in relation to an exploration of the internal resources in KC. Meanwhile, both the business and URI networks' absorptive capacities are addressed through exploring external network resources in KC formation.

The inventive capacity is the part of a knowledge exploration capacity that deals with the development of KC resources through the internal resources of the firm. Laosirihongthong et al (2014) suggested that the internal resource capability of the firm to explore knowledge forms a critical part of innovation and business value creation. Lichtenthaler & Lichtenthaler (2009) described the inventive capacity as involving the initial generation of a new idea through perceptions of particular opportunities; the firm then sets up a knowledge exploration strategy, which should integrate this new knowledge into their knowledge base. This is done through establishing links to existing knowledge. However, since knowledge is the core component of the innovation process, Laosirihongthong et al (2014) argued that the firm needs to stimulate and improve knowledge of their HC so as to prepare themselves for the dynamism of the technology marketplace. In this regard, knowledge is considered intellectual capital, which is embedded in HC. As a result, Laosirihongthong et al (2014) suggested that the process should involve hiring educated and experienced staff, training and improving communication, and information-sharing among individuals in the firm. They stated that, through thesis processes, knowledge can be amplified and extended by intensive interactions amongst individuals. Amabile et al (1996) suggested that firms need to provide motivation and a supportive environment for their individual employees with avenues that encourage them to stimulate their creativity and generate new ideas. Laosirihongthong et al (2014) stated that this supportive environment can offer enabling conditions to bring out the individual creativities of employees and easily transform this into business value for innovation. They argued that the most successful, innovative firms consider the facilitation of creativity and idea generation through encouraging cross-functional teamwork activities and providing rewards and incentives to develop the motivation to innovate. Furthermore, Laosirihongthong et al (2014) suggested that the combination of knowledge and creativity management represents a critical process in developing the innovative capital of a firm. (Subramaniam & Youndt, 2005) also confirmed that knowledge is the major organisational capital required for innovation.

On the other hand, with regard to the business and URI networks', the study approaches the concept of absorptive capacity as knowledge that is mainly acquired through external exploration (Podmetina & Smirnova, 2013). In this context, the absorptive capacity in knowledge exploration refers to the development of KC resources through external means, outside the firm's boundary. Lichtenthaler & Lichtenthaler (2009) described the absorptive capacity as the ability of firms to explore external knowledge. This is in line with popular research by Zahra & George (2002) who described this capacity as a potential and realised absorptive capacity. The potential absorptive capacity here means knowledge acquisition, while the realised absorptive capacity means the acquired knowledge in the firm.

Therefore, the common feature in all the above definitions is the fact that the absorptive capacity deals with external resource networks (Laosirihongthong et al, 2014). Laosirihongthong et al (2014) highlighted the significance of establishing a network with external partners to achieve a competitive advantage in innovation. The idea that knowledge that leads to innovation can best be jointly developed by firms and their supply chain partners is based on the notion that it can promote the capabilities of the collaborating firms in learning, coordinating and integration (Laosirihongthong et al, 2014). Such dynamic capabilities are important in building, integrating, and reconfiguring resources to adapt to rapidly changing environments (Leonard-Barton, 1992) . Laosirihongthong et al (2014) further suggested that external partners play a vital role in determining innovation performance, and argued that the early involvement of stakeholders in the innovation process positively impacts the speed of the uptake and acceptance of the innovation. This is particularly true in the BIM adoption process (Kiviniemi, 2011) .

3.3.4.1.1 Hypotheses and Sub-Hypotheses: Knowledge Exploration Capacity

Given the above, the study postulates the following hypotheses which is also illustrated in Figure 10;

$H11_1$: The knowledge exploration capacity an SME architectural firms has a significant correlation with BBVC.

$H11_0$: The knowledge exploration capacity of SME architectural firms has no significant correlation with BBVC.

Sub-Hypotheses;

- *H11a: Firms that have an* ***internal inventive capacity*** *to generate and integrate new knowledge are likely to succeed in BBVC*
- *H11b: Firms that have a* ***network absorptive capacity*** *to acquire and assimilate new knowledge are likely to succeed in BBVC*
- *H11c: Firms that have a* ***URI absorptive capacity*** *to acquire and assimilate new knowledge are like to succeed in BIM adoption*

3.3.4.2 KNOWLEDGE RETENTION CAPACITY

The identification of the knowledge retention capacity as a component of KC is based on the notion that, its classification into exploration and exploitation (Lu & Sexton, 2009) is not sustainable for the long-term competitive advantage for SME architectural firms, nor ultimately sustainable for innovation (Lichtenthaler & Lichtenthaler, 2009). This is particularly the case for BIM innovation. Thus, the knowledge retention capacity is what connects the process of both exploration and exploitation and ensures integral knowledge transfer, which ultimately yields the new process of competitive advantage. In this context, three indicators define the component: the transformative capacity, the business network connective capacity, and the URI network connective capacity.

With regard to the transformative capacity, Garud & Nayyar (1994) described it as the capability of a firm to internally retain knowledge over time. Lichtenthaler & Lichtenthaler (2009) suggested that knowledge can be lost if skills, experience and process built during activity routines are not properly retained, especially when an employee with such qualities leaves the firm. Therefore, Lane et al (2006) suggested that knowledge retention needs to be actively managed through assigning resources to keep knowledge ‘alive’. Lichtenthaler & Lichtenthaler (2009) highlighted the term ‘transformative capacity' as an indication that knowledge can be transformed if firms maintain knowledge over time and subsequently reactivate it. Hence, in this context, the knowledge transformative capacity can be defined as the ability of a firm to retain knowledge within its internal capacity.

On the other hand, the business and the URI connective capacities are considered integral elements for knowledge retention in innovation. This is based on the notion that, when firms endeavour to engage in an innovative process, they are faced with a major strategic consideration, and this is whether to exploit existing competencies to provide them with only short term success. This can become a hindrance to the firm's long-term viability by stifling the exploration of new competencies (Su et al, 2009); hence, the idea of connective capability through inter-organisational relationships arises, where such alliances are considered to represent the firm’s external knowledge retention (Lichtenthaler & Lichtenthaler, 2009). Similarly, a transformative capacity deals with retaining knowledge within a firm’s internal resources. Kale & Singh (2007) suggested that a connective capacity deals with retaining knowledge through external relationships with businesses and URIs partners. There are two types of relationship involved in connective capacity, which are alliance capability (Kale & Singh, 2007), and relational capability (Lorenzoni & Lipparini, 1999). However, Lichtenthaler & Lichtenthaler (2009) highlighted that a firm that maintains external knowledge does not often assume an inward knowledge transfer to through any absorptive capacity. Instead, it is a relationship that allows firms to ensure privileged access to external knowledge without acquiring it, and this is very common in the case of URIs (Su et al, 2009). However, according to Chesbrough (2013), in order for the firm to enjoy such privileges, they often need to be open to transfer some of their knowledge.

Su et al (2009) emphasised that such connective capacity significantly impacts on successful innovation in SME architectural firms arguing that firms with a connective capacity, both in business and URIs networks, could record a higher competitive advantage of learning ‘outside the box’, and ultimately improving their innovation capability. A similar view is shared by Laosirihongthong et al (2014) who highlighted its criticality for a successful innovations process.

3.3.4.2.1 Hypotheses and Sub-Hypotheses: Knowledge Retention Capacity

Hence given this context, this study postulates the following hypotheses which is also illustrated in Figure 10;

$H12_1$: The knowledge retention capacities of SME architectural firms have a significant correlation with BBVC.

$H12_0$: The knowledge retention capacities of SME architectural firm have no significant correlation with BBVC.

Sub-Hypothesis;

- *H12a: Firms that have the **transformative capacity to internally maintain and reactivate knowledge** for continued use are likely to succeed in BBVC.*
- *H12b: Firms that have the **connective capacity through alliance and cooperation with external partners to maintain and reactivate knowledge** for continued use are likely to succeed in BBVC.*
- *H12c: Firms that have the **connective capacity through alliance and cooperation with URIs to maintain and reactivate knowledge** for continued use are likely to succeed in BBVC.*

3.3.4.3 KNOWLEDGE EXPLOITATION CAPACITY

Lu & Sexton (2006) described an exploitative knowledge capacity as the ability of SME architectural firms to utilise their organisational resources through KC to improve their organisational efficiency and generate short-term competitive advantage. Lichtenthaler & Lichtenthaler (2009) suggested that such utilisation can involve the reiteration of different strategies in a diverse context and their internal and external applications in various settings. Lu & Sexton (2009) highlighted the importance of the exploitative capacity of SME architectural firms in creating a competitive advantage through an explicit focus on long-term value creation for innovation, but still giving short-term advantage. In this study, two indicators are identified as the internal and external exploitative capacities. The former explicitly deals with the internal utilisation of knowledge that is explored and retained; it is either inventive or absorptive, as well as transformative or connective, and improves organisational efficiency by generating a short-term competitive advantage (Lichtenthaler & Lichtenthaler, 2009; Lu & Sexton, 2009). An internal exploitative capacity involves the process of transmuting knowledge and converting it into new products or services (Khilji et al, 2006).

On the other hand, the external exploitative capacity of KC refers to the ability of a firm to identify an exploitation opportunity outside the firm's boundaries, and the process of transferring the KC of the firm outside through a product delivery or alliance. Lichtenthaler & Lichtenthaler (2009) described the external exploitative capacity as an outward knowledge transfer, which has recently become a broader trend due to the non-rivalry of knowledge. An external knowledge exploitation capacity does not preclude its internal application. After identifying external knowledge exploitation opportunities based on the commercial and strategic motives for transferring knowledge, a firm has to transfer the knowledge to the recipient.

3.3.4.3.1 Hypotheses and Sub-Hypotheses: Knowledge Exploitation Capacity

Hence, the following hypotheses are developed for this study which is also illustrated in Figure 10;

$H13_1$: The knowledge exploitation capacity of an SME architectural firm has a significant correlation with BBVC.

$H13_0$: The knowledge exploitation capacity of an SME architectural firm has no significant correlation with BBVC.

Sub-Hypotheses;

- *H13a: Firms that have an **internal exploitation capacity** to transmute new knowledge into value are likely to succeed in BBVC.*

- *H13b: Firms that have an **external exploitation capacity** to identify knowledge value and to transfer to external partners internally are likely to succeed in BBVC*

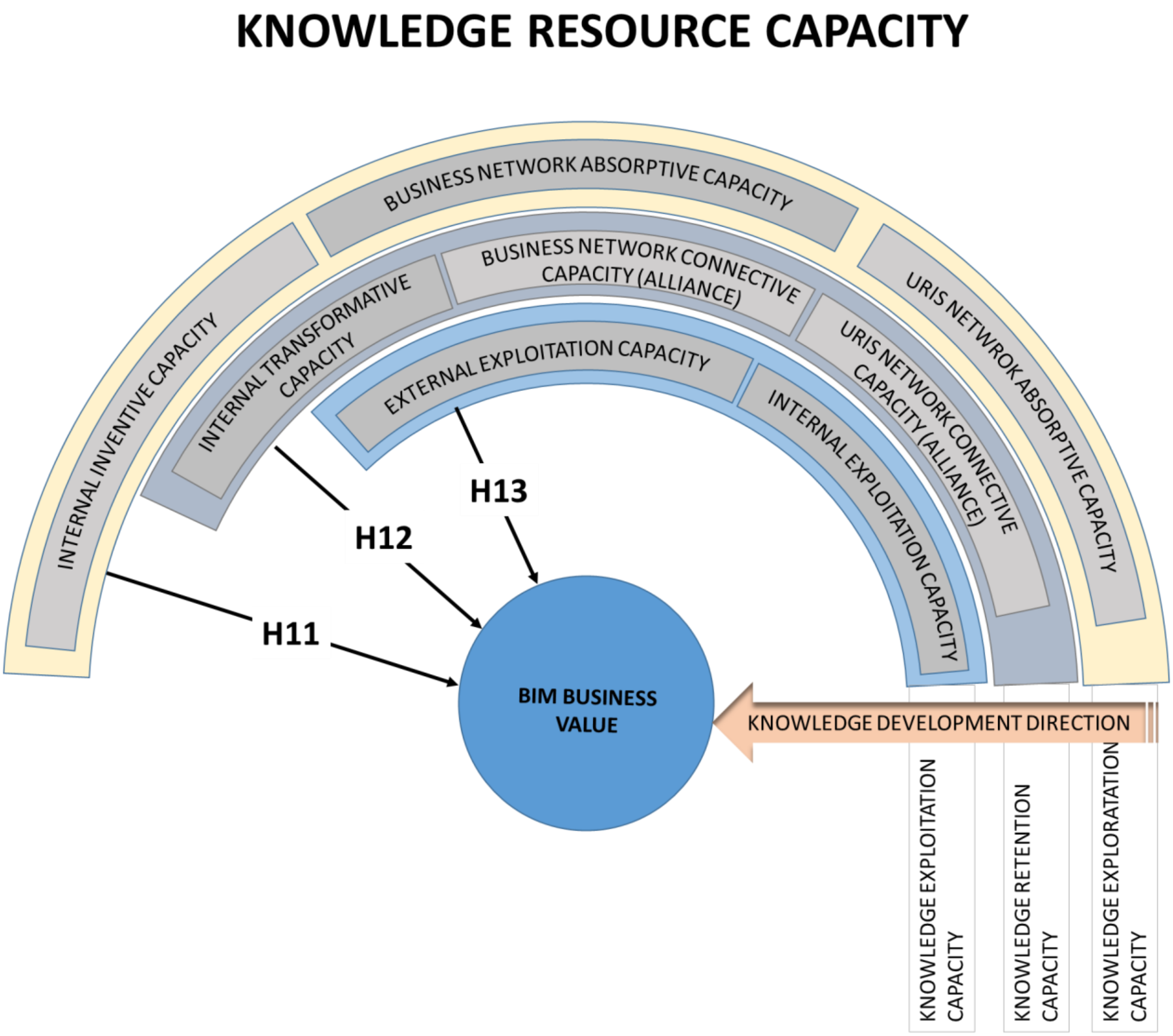

Figure 10: A model for KC components of BIM adoption in SME architectural firms

3.4 THE DEPENDENT VARIABLE: MEASURE OF BIM SUCCESS IN THE SME ARCHITECTURAL FIRMS.

This section discusses the dependent variable of the study, which is BBVC. It starts by defining BIM from the business perspective, and the emergence of the term 'business value' in BIM. Subsequently, the study defines the term BBVC through the literature of IT business value and built its case from that field.

Vass (2015) suggested that most studies on measuring business value in the field focus on evaluating the value of IT. Others concentrate on determining suitable metrics or key performance indicators to measure and evaluate the effects of implementing IT, and in particular to measure any increased productivity from IT. This is also true in the case of current construction management and BIM research (Aranda-Mena et al, 2009; Barlish & Sullivan, 2012; Construction, 2014; Vass, 2014). For example, Curley (2004) explicitly states that, in order to measure the business value of IT in a firm, a maturity and capability metric is essential. This is also reiterated by Succar (2009) and Aranda-Mena et al (2009) who argued that generating business value through BIM is highly dependent on the individual capabilities of firms Similarly, McGraw-Hill (2009) suggested that numerous successful firms invest to make sure clients are aware of their BIM capabilities in order to create business value. All the above assertions point to the level of maturity and capability as essential in generating IT business value. (Curley, 2004; Kohli & Grover, 2008; Racheva et al, 2009).

3.4.1 BIM MATURITY AND CAPABILITY MODEL

Measurement of BIM success or maturity models in firms has well been established in the literature; it was early started by the National BIM Standard Capability Maturity Model (NBIMS-CMM), developed in the U.S. by the National Institute of Building Sciences (NIBS, 2007). NBIMS-CMM consists of eleven critical BIM measures, including business process, delivery method, data richness and information accuracy. It focuses only on information management and has been therefore criticised for not reflecting the diverse facets of BIM. Critics have also questioned its usefulness and usability due to its structural limitations (Succar, 2010). So profound and powerful these critics were and resulted in the introduction of new models that tried to build on NBIM-CMM and provide more optimised models. However, following the success of the UK BIM Task Group over the past years in defining and implementing BIM Level 2 within Government Departments. The emergence of new models seeks better ways of measuring BIM. Frameworks such as the BIM Maturity Matrix (Succar, 2010), the Virtual Design and Construction (VDC) Scorecard (Kam, 2015) and the BIM Maturity Measure (BIMMM) (Ammar et. al, 2017), have been designed to improve previous models. They have supplemented past measures with diverse areas of measurement that represent much broader dimensions of BIM e.g. policies, technologies and processes. Individually and collectively, coexisting AMs have contributed to the growing body of literature that examines BIM use.

In order to develop the measure for BBVC based on these various models and efforts, it is important to reflect on all the existing maturity models/indices of maturity and capability concerning the BIM process.

Numerous models contribute to the development of viable BIM maturity and capability models. Among them are; Control Objects for Information and Related Technology, CMMI (Capability Maturity Model Integration), CSCMM (Construction Supply Chain Maturity Model), I-CMM (Interactive Capability Maturity Model), Knowledge Retention Maturity Levels, LESAT (Lean Enterprise Self-Assessment Tool), P3M3 (Portfolio, Programme and Project Management Maturity Model), PCMM® (People Capability Maturity Model), $(PM)^2$ (Project Management Process Maturity Model), SPICE (Standardised Process Improvement for Construction Enterprises), Supply Chain Management Process Maturity Model, and BPO (Business Process Orientation Maturity Model). These models as listed in (Succar et al, 2012) were studied by Kori & Kiviniemi (2015) with regard to BIM in Nigeria, and the outcome was that most of these models were broad in approach and could collectively form a basis for a range of BIM capabilities. However, Succar (2009) suggested there is not enough differentiation between the notion of capability and that of maturity. Hence Succar (2009) defines 'BIM maturity' as, "the quality, repeatability and degree of excellence within a BIM capability and developed the BIM Maturity Matrix". Succar described BIM capabilities in three stages:

1) Object-based modelling;

2) Model-based collaboration; and

3) Network-based integration.

Barlish & Sullivan (2012) highlighted that it is the extent of an organisation's performance or ability within a particular stage that is measured to determine their BIM maturity. This is gauged according to the five maturity levels shown in Figure 11: BIM maturity levels at different stages

The BIM maturity level at Stage 1, for example, indicated an organisation performing testing or pilot projects to determine the benefits of BIM (Barlish & Sullivan, 2012); this is the first stage (object-based modelling) and within that phase they are at an ‘ad-hoc’ or ‘defined’ maturity level, working for more optimisation through increasing testing. Furthermore, the organisation's level of BIM maturity can be accessed via general objectives within a level similar to Figure 11: BIM maturity levels at different stages

Figure12: The BIM Maturity Map by Bew & Richards (2008) in BIM Overlay to the RIBA Outline Plan of Work (Sinclair, 2012), or matrix of competencies, is similar to Building SMART Alliance's BIM Capability Maturity Model. Organisations' varying levels of maturity should be taken into consideration when comparing organisations’ BIM business cases.

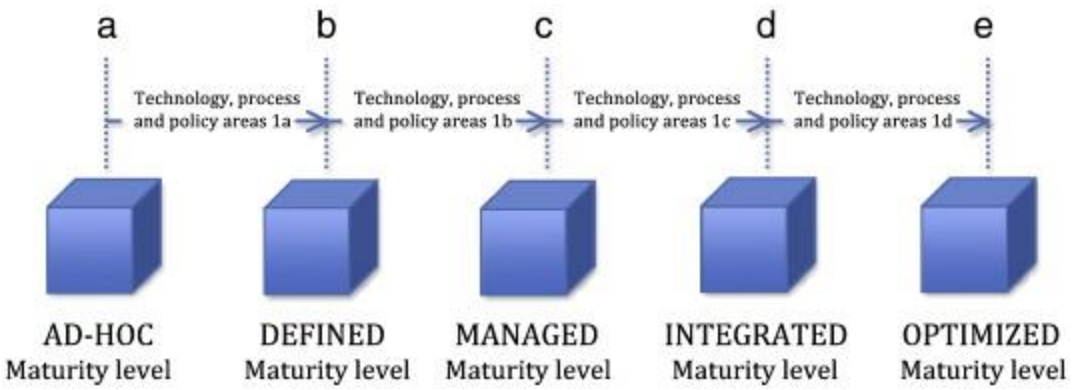

Figure 11: BIM maturity levels at different stages

(Barlish & Sullivan, 2012)

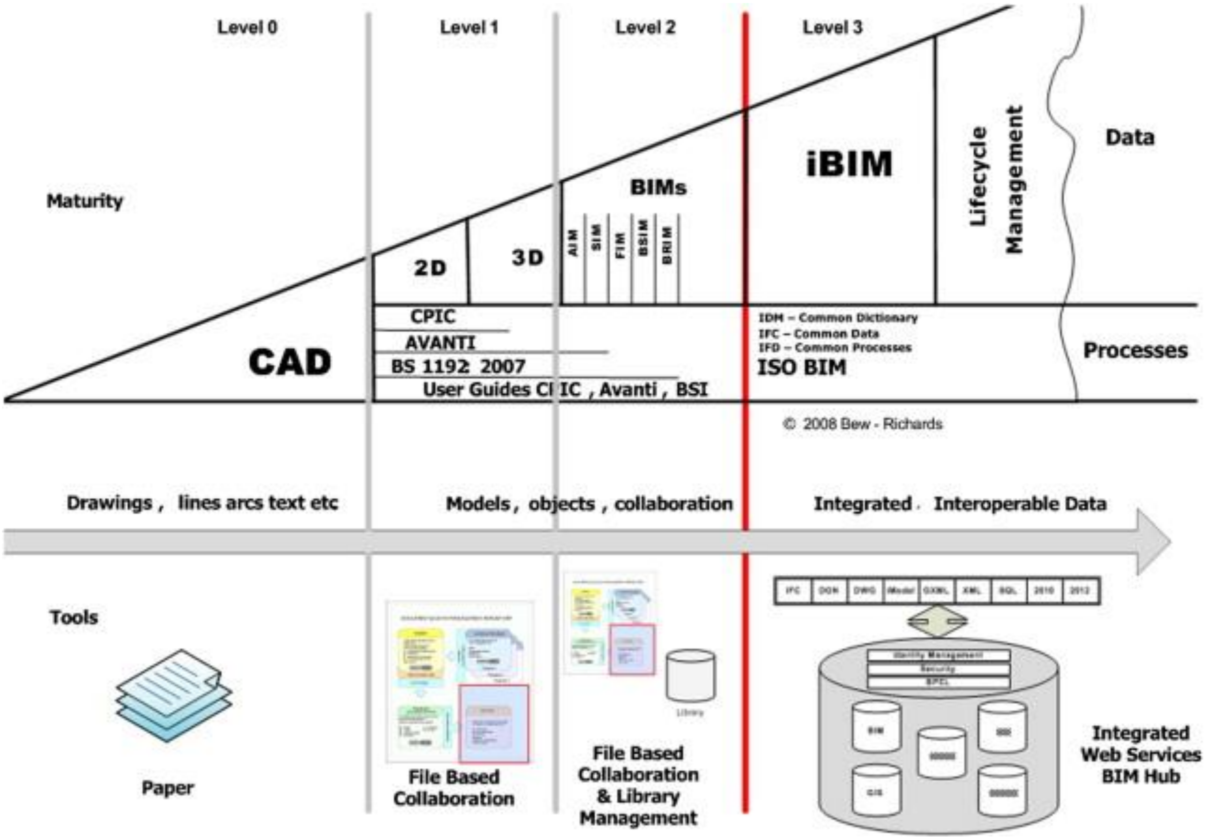

Figure 12: BIM Maturity Map

(Bew & Richards, 2008)

Consequently, in accordance with the BIM Maturity map by Bew & Richards (2008) having identified the BIM fields, Succar (2009) further developed five stages which delineate capability milestones. Succar (2009) describes BIM capability as the basic ability to perform a task, deliver a service, or generate a product. BIM capability stages (or BIM stages) define the major milestones for achievement by teams and organisations as they adopt BIM technologies and concepts. BIM stages identify a fixed starting point (the status before BIM implementation), three fixed BIM stages, and a variable ending point, which allows for unforeseen future advancements in technology. The following is a list and description of each of the five stages developed in accordance with Succar & Kassem (2015) BIM Maturity Matrix, which is subsequently used as the baseline in developing the measure of BBVC for this study.

0. **Pre-BIM status:** *Disjointed Project Delivery*

The construction industry is characterised by adversarial relationships where contractual arrangements encourage risk-avoidance and risk-shedding. Much dependence is placed on 2D documentation to describe a 3D reality. Even when some 3D visualisations are generated, these are often disjointed and reliant on two-dimensional documentation and detailing. Quantities, cost estimates and specifications are neither derived from the visualisation model nor linked to documentation. Similarly, collaborative practices between stakeholders are not prioritised and workflow is linear and asynchronous. Under pre-BIM conditions, the industry suffers from low investment in technology and a lack of interoperability.

1. **BIM Stage 1:** *Object-Based Modelling*

Collaborative practices at Stage 1 are similar to the pre-BIM status and there are no significant model-based interchanges between different disciplines. Data exchanges between project stakeholders are uni-directional and communications continue to be asynchronous and disjointed. As only minor process changes occur at Stage 1, pre-BIM contractual relations, risk allocations and organisational behaviour persist. However, the semantic nature of object-based models and their 'hunger' for early and detailed resolutions of design and construction challenges encourage the 'fast-tracking of project lifecycle phases - when a project is still executed in a phased manner yet design and construction activities are overlapped to save time.

2. **BIM Stage 2:** *Model-Based Collaboration*

Although communication between BIM players continue to be asynchronous, pre-BIM demarcation lines separating roles, disciplines and lifecycle phases start to fade. Some contractual amendments become necessary as model-based interchanges augment and start replacing document-based workflows. Stage 2 also alters the granularity of modelling performed at each lifecycle phase as higher-detail construction models move forward and replace (partially or fully) lower-detail design models.

3. **BIM Stage 3:** *Network-Based Integration*

At this capability stage, semantically-rich integrated models are created, shared and maintained collaboratively across project lifecycle phases. This integration can be achieved through 'model server' technologies (using proprietary, open or non-proprietary formats), single-integrated/distributed-federated databases, Cloud Computing or SaaS (Software as a Service). BIM Stage 3 models become interdisciplinary nD models allowing complex analyses at early stages of virtual design and construction. At this stage, model deliverables extend beyond semantic object properties to include business intelligence, lean construction principles, green policies and whole lifecycle costing. Collaborative work now 'spirals iteratively' around an extensive, unified and shareable data model. From a process perspective, a synchronous interchange of the model and document-based data cause project lifecycle phases to overlap extensively forming a phase-less process.

4. **Integrated Project Delivery:** *Interdependent, Real-Time Models*

This is the most suitable stage representing a long-term vision of BIM as an amalgamation of domain technologies, processes and policies. The term is generic enough and potentially more readily understandable by industry than 'Fully Integrated and Automated Technology', Integrated Design Solutions, or 'nD Modelling, as three prominent examples. The selection of Integrated Project Delivery (IPD) as the goal of BIM implementation is not to the exclusion of other visions appearing under different names. On the contrary, the path from Pre-BIM (a fixed starting point), passing through three well-defined stages towards a loosely defined IPD is an attempt to include all pertinent BIM visions irrespective of their originating sources.

Similarly, Aranda-Mena et al (2009) developed a model based on the Val IT approach (ITGI, 2006) identified three layers of capability:

a) Technical capability: the specific technological capabilities delivered by the programme.
b) Operational capability: the operational capabilities that are supported by the technological capabilities.
c) Business capability: the overall business capabilities enabled by the operational capabilities.

The discussion above provided a baseline for shaping an appropriate model that could fit the context of this study. However, because the study deals with SME architectural firms in a Nigerian context, there may be some layers and elements that might need to be re-evaluated and contextualised. Hence, the following discussion will focus on the contextualisation of the model.

3.4.2 THE SME ARCHITECTURAL FIRMS AND BIM MATURITY AND CAPBILITIY MODEL

SME architectural firms have unique characteristics with regard to BIM maturity and capability (Kori & Kiviniemi, 2015). Hosseini et al (2016) study of SME architectural firms in Australia is regarded as among the frontiers of BIM adopters (indeed, Kassem et al (2015) suggested that the immaturity of BIM implementation is still a problem in the industry). Hosseini et al's study indicated that an insignificant percentage of SME architectural firms use BIM Level 3, described by Succar (2009) as the ability stage, and only 8% utilise Level 2 BIM on their projects. Forsythe (2014) suggested that implementing integrated BIM with a satisfactory level of collaboration among stakeholders has remained a distant target for SME architectural firms and described the BIM capability of such firms as a, 'touch the BIM lightly' approach. The same has been reported in many other countries, for example the Netherlands (Leeuwis, 2012) and the United Kingdom (Ganah & John, 2014). These assertions are relevant as they explicitly suggest that the study and measure of capability of SME architectural firms tends to be limited to Level 2, and the situation in emerging markets, such as Nigeria, can only be more limited than the countries listed above (Kassem et al, 2013).

3.4.3 CONTEXTUAL METRIC FOR THE BBVC

The study identified five stages of BBVC within SME architectural firms in Nigeria. The scale is based on the notion of maturity and capability metrics discussed above. This identification is based on the degree of ICT technology usage of firms for BBVC creation. However, the research question involves identifying how BIM adopters differ from non-adopters in how they develop their intellectual capitals. Thus, it is important to include stages that have no value creation for BIM, which can represent the non-BIM adopters, and on an increasing scale also represent the BIM adopters. Thus, these five levels are described below and shown in Figure 13: Scale for measuring the BBVC used for the study

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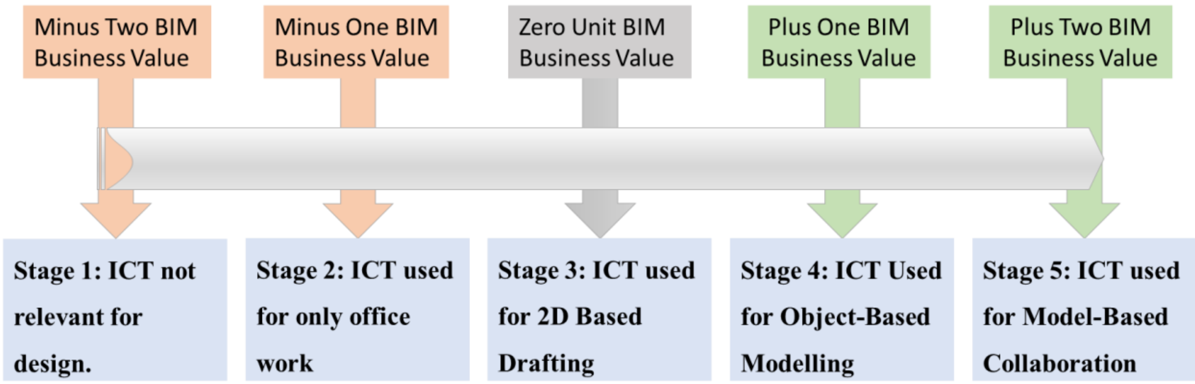


Figure 13: Scale for measuring the BBVC used for the study

In rating the level of the BBVC by the SME Architectural firms on the questionnaire instrument, it is essential to use the interval rating system which allows the study to understand the ranking difference between those firm that are capable in achieving the BBVC and those that are not. To do that, the study assigned 'Minus two (-2)' showing the least of those not capable to a middle point where there is Zero BBVC. The Zero in this context doesn't refer to 'nothing' rather it is 'arbitrary' meaning a midpoint, and then 'Plus Two (+2) as those with the highest capability of BBVC. This gives the study the room to understand the variance in the data and to perform the regression analysis which is the proposed analysis method for the approach.

- **Stage 1: ICT not relevant for design.**

The firm in this stage is characterised by a traditional approach to design and communication; conservativeness is high, and the firm does not have the capability to create any BBVC. Hence, a firm at this stage has a negative BBVC creation. The numbering system on the top line shows the scale used in collecting the data from the field.

- **Stage 2: ICT used for only office work**

The firm at this stage uses ICT for office work, such as emails, word processing, scanning, printing and photocopying, among others. A firm at this stage is similar to one in Stage 1 in its negative value creation for BIM.

- **Stage 3: ICT use for 2D Based Drafting**

This stage represents the use of 2D hand-drawn, 2D computer-aided drafting or 3D non-object based software technologies, similar to AutoCAD® and SketchUP®. The use of 2D CAD files for production information is a process that the majority of design practices have been used for many years.

- **Stage 4: ICT use for Object-Based Modelling**

Level 1 represents a single-disciplinary 3D model exemplified by an architect's ArchiCAD®, a structural engineer's Revit® or a steel detailer's Tekla® model. BIM implementation is initiated through the deployment of an object-based 3D parametric software tool, for example ArchiCAD®, Revit®, Digital Project® and Tekla®. At this stage, users generate single-disciplinary models within design, construction or operations – the three project lifecycle phases. Modelling deliverables include architectural design models, and duct fabrication models are used primarily to automate the generation and coordination of 2D documentation and 3D visualisation. Other deliverables include basic data exports (e.g. door schedules, concrete volumes, FFE costs,) and lightweight 3D models (e.g. 3D DWF, 3D PDF, NWD, etc.), which have no modifiable parametric attributes.

- **Stage 5: ICT used for Model-Based Collaboration**.

This stage represents the interchange of 3D models between two different disciplines. This can be exemplified by a two-way linking of Revit® Architectural and Structural models (a proprietary interoperable exchange) or the interchange of IFC files exported out of multi-disciplinary BIM applications (a non-proprietary interoperable exchange). Having developed single-disciplinary modelling expertise during Stage 4 implementation, those involved at this stage actively collaborate with other disciplinary players. Collaboration may occur in several technical ways following each player's selection of BIM software tools. Two different examples of model-based collaboration include exchanging models or part-models through 'proprietary' formats (e.g. between Revit® Architecture and Revit® Structure through the RVT file format) and non-proprietary formats (e.g. between ArchiCAD® and Tekla® using the IFC file format).

3.5 THE OVERALL EVALUATION FRAMEWORK

Based on the discussions on the aspect of the IC developments and the BBVC, the study developed the overall evaluation framework as presented in Figure 14 below. This is achieved through combining the four (4) models from the HC, RC, SC and KC. The overall evaluation framework gives a conceptual explanation for the areas of empirical enquiry in the study. It also depicts the 13 hypotheses that require empirical testing.

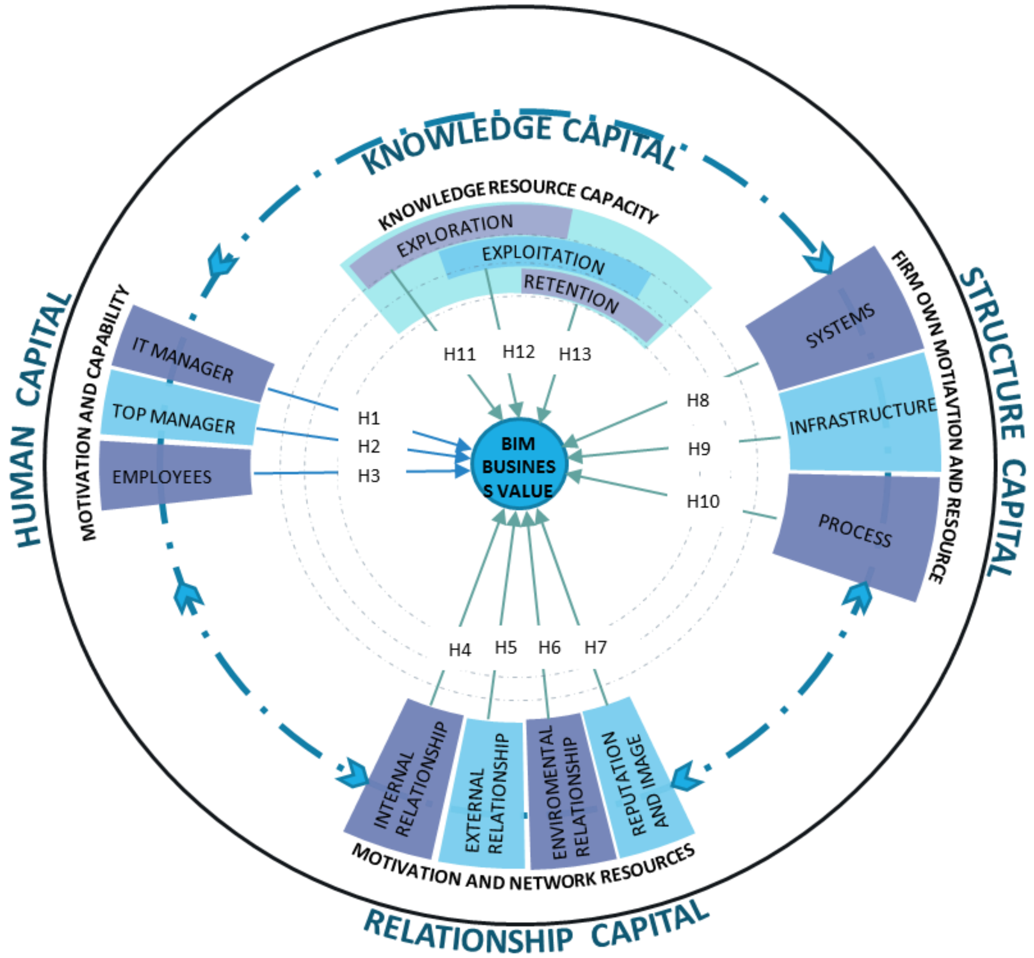


Figure 14: Hypothetical framework for BBVC through IC of SME architectural firms

3.6 CHAPTER SUMMARY

The chapter presented a systematic literature review on the two main variables of the study, namely, the independent and the dependent variable. On the one hand, it is the independent variables which the study began with the identification of thirteen components under the four aspects (Human, Relationship, Structure and Knowledge Capitals) of IC, which are positioned to be relevant in affecting BBVC. The HC aspect comprises three of these components, which are: the motivation and capability of the IT manager, top manager and employees. The RC aspect comprises four components, which are the motivation and network resource resulting from internal, external and, environmental relationships, and from image and reputation. The SC aspect comprises three components, which are: the capability and support of the firm's system structure, the infrastructural facilities, and the process schemes employed by the firm. The KC aspect comprises three components, which are the: knowledge exploration, knowledge exploitation and knowledge retention capacities. Through the literature review, these components were further divided into a set of indicators to form the unit elements of the IC. On the other hand, which is the dependent variable of BIM Business Value Creation (BBVC), the study developed metrics based on the BIM capability stages of firm. These identifications and metrics enabled the development of an evaluation framework for BBVC through the IC in SME architectural firms. In each case of the thirteen components, a hypotheses and a sub-hypotheses is formulated to enable assessment. **Error! Reference source not found.** illustrates how the different elements and the components of the independent variables are positioned with the dependent variables of the BBVC as a proposition for the study.

4 CHAPTER FOUR: SURVEY STUDY ANALYSIS

4.1 CHAPTER OVERVIEW

This chapter discusses the data analysis and results related to the survey of this study. The analysis involves the evaluation of the theoretical model developed from the research framework in Chapter Three. The chapter starts with a recap of the theoretical model developed, and this is followed with a short introduction of the process involved in conducting the regression analysis. The main analysis section is divided into four; each of these sections represent the analysis related to one of the four elements of the IC. In each case, a regression analysis tables of Model summary, Anova and the Coefficient is presented together with their related discussion, whereas, at the end, the conclusion for each section is discussed. In the end of the chapter, the summary of the overall findings is then presented.

4.2 OVERVIEW OF THE THEORETICAL MODEL

In Chapter Three, the theory formulation is achieved through proposing an evaluation framework using a systematic review of literature on the four elements of the IC. The evaluation framework constitutes a set of independent variables comprising thirteen components categorised under the four elements. Each of the components was defined by a set of indicators. Through the evaluation framework, each component and its set of indicators are used to formulate a hypothesis, thus developing 13 hypotheses with various sub-hypotheses. In this chapter, the survey data is used to evaluate the framework through assessing each hypothesis using multiple regression analysis. Each component with its sets of indicators represent an independent model of regression in the analysis. The outcome provides statistical evidence of the relationship between the two main variables. Also, it provides the Relative Weighting Value (RWV) for each indicator in relation to the components and their effects on BBVC. There are thirteen components in the model (shown in Figure 16) with 41 indicators.

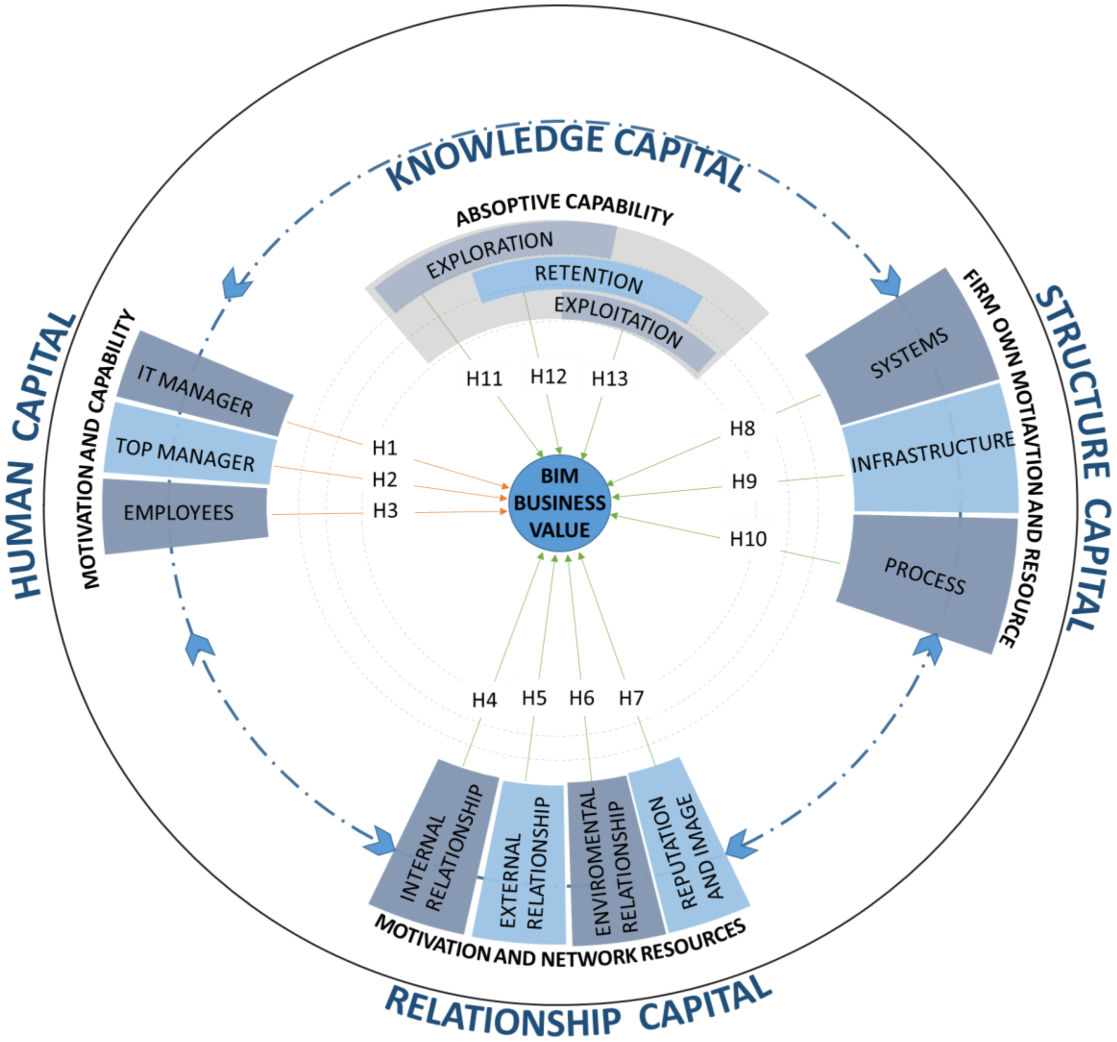


Figure 15: Theoretical model for the BIM-based innovation showing the hypotheses formulated for analysis

4.3 ANALYSIS OF HUMAN CAPITAL (HC) COMPONENTS

This part deals with the HC aspect of the analysis. It involves analysing the three component of HC, as shown in Figure 15: Theoretical model for the BIM-based innovation showing the hypotheses formulated for analysis

1. The first component is the motivation and capability of the IT manager, which comprises four indicators as follows;

    a. nature of employment,
    b. the level of education,
    c. previous experience,
    d. job satisfaction.
2. The second component is the motivation and capability of the top manager in the firm, which also comprises four indicators, as follows;
    a. strategic knowledge of innovation,
    b. non-resistance to change,
    c. the ability to inspire others,
    d. the quality of teamwork.
3. The third component is the motivation and capability of the employees, which also comprises four indicators, as follows;
    a. regular training,
    b. shared innovative value,
    c. willingness to accept innovation,
    d. self-motivation.

The analysis tests each of these indicators as an independent variable against the dependent variable of the BBVC. Hence, each component is treated as an independent model of regression with the indicators as predictors.

4.3.1 THE IT MANAGER COMPONENT

This section presents the analysis of the relationship between motivation and capability of an IT manager in SME architectural firms and the BBVC. Table 4 lists the variables of the IT manager components.

4.3.1.1 HYPOTHESES

$H1_1$: The motivation and capabilities of IT managers toward innovation in SME architectural firms has a significant correlation with BBVC.

$H1_0$: The motivation and capabilities of IT managers toward innovation in SME architectural firms has no significant correlation with BBVC.

4.3.1.1.1 Sub-Hypotheses

- *H1a: Firms that develop their innovation HC from IT managers with a* ***flexible work life balance*** *are likely to succeed in BBVC.*
- *H1b: Firms that develop their innovation HC from IT managers with* ***higher education qualifications*** *are likely to succeed in BBVC.*
- *H1c: Firms that develop their innovation HC from IT managers with* ***previous experience*** *are likely to succeed in BBVC.*
- *H1d: Firms that develop their innovation HC from IT managers with* ***higher job satisfaction*** *are likely to succeed in BBVC.*

Table 4: Variables of the IT manager component

<table>
<tr><td colspan="3">INDEPENDENT VARIABLES</td><td>DEPENDENT VARIABLES</td></tr>
<tr><td>Component Level</td><td colspan="2">The motivation and capability of IT manager</td><td rowspan="5">BIM Business Value Creation (BBVC)</td></tr>
<tr><td rowspan="4">Indicators Level</td><td>1</td><td>The IT managers has flexible work life balance</td></tr>
<tr><td>2</td><td>The IT managers has higher education qualification</td></tr>
<tr><td>3</td><td>The IT manager previous IT experience.</td></tr>
<tr><td>4</td><td>The IT managers has higher job satisfaction</td></tr>
</table>

4.3.1.2 THE REGRESSION ANALYSIS

A multiple regression analysis is conducted to investigate whether the motivation and capabilities of IT managers toward innovation in SME architectural firms have a significant correlation with BBVC. This involves analysing the effect of four indicators of the IT manager in predicting the BBVC. The preliminary analysis shows that all assumptions are valid and the potential variables of the indicators are accepted to carry out the multiple regression analysis.

Table 5: Model summary for the IT manager component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.723[a]	.523	.515	.99177

a. Predictors: (Constant), The IT managers have higher job satisfaction; The IT managers have higher education qualifications, The IT managers have previous IT experience. The IT managers have a flexible work life balance

Table 5 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.515 with the $R^2 = 0.523$, which means that the linear regression explains 52.3% of the variance in the data.

Table 6: Anova test for the IT manager component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	240.918	4	60.229	61.233	.000b
	Residual	219.345	223	.984		
	Total	460.263	227			

a. Dependent Variable: BBVC

b. Predictors: (Constant), The IT managers have higher job satisfaction; The IT managers have higher education qualifications, The IT managers have previous IT experience. The IT managers have a flexible work life balance

Table 6 shows the linear regression's F-test which has the null hypothesis, $H1_0$ that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows a F value of 61.233 with highly significant P-value; thus, the study can assume that the null hypothesis $H3_0$ is rejected. Hence, $H1_1$ is accepted, which means that, at the components level, there is a significant linear relationship between the motivation and capability of the IT manager and the BBVC in an SME architectural. However, to determine the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the level of the indicator is presented in Table 7.

Table 7: Coefficient showing the linear regression estimates of all the indicators of the IT manager components on BBVC

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	.835	.168		4.976	.000
The IT managers have a flexible work life balance	.285	.094	.307	3.042	.003
The IT managers have higher education qualifications	.425	.092	.448	4.612	.000
The IT managers have previous IT experience.	.178	.090	.179	1.988	.048
The IT managers have higher job satisfaction	.432	.080	.433	5.366	.000

a. Dependent Variable: BBVC

Table 7: Coefficient showing the linear regression estimates of all the indicators of the IT manager components on BBVC shows the multiple linear regression estimates of all the indicators, thus testing the four Sub-Hypotheses, H1a-H1d, including the intercept and the significance levels, on the effect of each indicator on the IC of BBVC. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. Table 7 shows there is a significant positive effect on BBVC when firms rely on the motivation and capability of an IT manager regarding a higher educational qualification, previous IT experience, higher job satisfaction and a flexible work life balance.

4.3.2 THE TOP MANAGER COMPONENT

This section presents the analysis of the relationship between motivation and capability of the top manager in SME architectural firms and the BBVC. Table 8 lists the variables of the top manager component.

4.3.2.1 HYPOTHESES

H2$_1$: The motivation and capabilities of top managers regarding innovation have a significant correlation with BBVC in SME architectural firms

H2$_0$: The motivation and capabilities of top managers regarding innovation have no significant correlation with BBVC in SME architectural firms.

4.3.1.1.2 Sub-Hypotheses

- *H2a: Firms that develop their innovation HC from top managers with **strategic knowledge of innovation** are likely to succeed in BBVC.*
- *H2b: Firms that develop their innovation HC from top managers with **non-resistance to change** are likely to succeed in BBVC.*
- *H2c: Firms that develop their innovation HC from top managers with **the ability to inspire others** are likely to succeed in BBVC.*
- *H2d: Firms that develop their innovation HC from top managers with **the quality of teamwork** are likely to succeed in BBVC.*

Table 8: Variables of the top manager component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The motivation and capability of top managers		
Indicators Level	1	Strategic knowledge of innovation	BIM Business Value Creation (BBVC)
	2	Non-resistance to change	
	3	The ability to inspire others	
	4	The quality of teamwork	

4.3.2.2 THE REGRESSION ANALYSIS

A multiple regression analysis is conducted to investigate if the motivation and capabilities of top managers toward innovation in SME architectural firms have a significant correlation with success in BIM adoption. This involves analysing the effect of four indicators of the top manager in predicting the success in the BIM adoption. Preliminary analysis shows that all assumptions are valid and the potential variables of the indicators are accepted to carry out the multiple regression analysis.

Table 9: Model summary for the top manager component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.757[a]	.573	.565	.93890

a. Predictors: (Constant), The quality of teamwork, Strategic knowledge of innovation, Non-resistance to change, The ability to inspire others

Table 9: Model summary for the top manager component shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.565 with the R^2 =0.573, which means that the linear regression explains 57.3% of the variance in the data.

Table 10: Anova test for the top manager component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	263.683	4	65.921	74.780	.000b
	Residual	196.580	223	.882		
	Total	460.263	227			

a. Dependent Variable: BBVC

b. Predictors: (Constant), The quality of teamwork, Strategic knowledge of innovation, Non-resistance to change, The ability to inspire others

Table 10: Anova test for the top manager component shows the linear regression's F-test, which has the null hypothesis $H2_0$ that there is no linear relationship between the dependent variables and independent variables at the relationship at the component level (in other words R^2=0). The F-test shows F value of 74.78 with a highly significant P-value; thus the study can assume that the null hypothesis $H2_0$ is rejected hence, $H2_1$ is accepted which means there is a significant linear relationship between the motivation and capability of the top manager in SME architectural firms and BBVC at the components level. However, to determine the

direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the level of the indicator is presented in Table 11.

Table 11: Coefficient showing the linear regression estimates of all the indicators of the top manager components on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.592	.170		3.480	.001
	Strategic knowledge of innovation	.180	.078	.172	2.304	.022
	Non-resistance to change	.219	.074	.218	2.972	.003
	The ability to inspire others	.020	.102	.019	.194	.846
	The quality of teamwork	.403	.080	.429	5.011	.000

a. Dependent Variable: BBVC

Table 11 shows the multiple linear regression estimates of all the indicators, thus testing the four sub-hypotheses, H2a-H2d, including the intercept and the significance levels on the effect of each indicator of the IC capital of BBVC. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that there is a significant positive effect on BBVC when firms rely on the motivation and capability of top managers who have strategic knowledge of innovation, demonstrate non-resistant to change and possess the quality of teamwork; however, the ability of the top manager to inspire others is not a significant predictor.

4.3.3 THE EMPLOYEES COMPONENT

This section presents the analysis of the relationship between motivation and capability of employees in SME architectural firms and BBVC. Table 12 lists the variables of the employee component.

4.3.3.1 HYPOTHESES

$H3_1$: The motivation and capabilities of the employees of SME architectural firms regarding innovation have a significant correlation with BBVC.

$H3_0$: The motivation and capabilities of the employees of SME architectural firms regarding innovation have no significant correlation with BBVC.

4.3.1.1.3 Sub-Hypotheses

- *H3a: Firms that develop their innovation HC from employees* ***with regular training*** *are likely to succeed in BBVC.*
- *H3b: Firms that develop their innovation HC from employees* ***with shared innovative value*** *are likely to succeed in BBVC.*
- *H3c: Firms that develop their innovation HC from employee's* ***willingness to accept innovation*** *are likely to succeed in BBVC.*
- *H3d: Firms that develop their innovation HC from employees* ***with self-motivations*** *are likely to succeed in BBVC.*

Table 12: Variables of the employees component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The motivation and capability of employees		
Indicators Level	1	Employees with regular training	BIM Business Value Creation (BBVC)
	2	Employees with shared innovative value	
	3	Employees with willingness to accept innovation	
	4	Employees with self-motivations	

4.3.3.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate if the motivation and capabilities of employees toward innovation in SME architectural firms have a significant correlation with success in BIM adoption. This involved analysing the effect of four indicators concerning employees in predicting the success in the BIM adoption. Preliminary analysis shows that all assumptions are valid and the potential variables of the indicators are accepted to carry out the multiple regression analysis.

Table 13: Model summary for the employee's component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.764a	.584	.577	.92629

a. Predictors: (Constant), Employees with self-motivations, Employees with regular training, Employees with willingness to accept innovation, Employees with shared innovative value

Table 13 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.577 with the $R^2 = 0.584$, which means that the linear regression explains 58.4% of the variance in the data.

Table 14: Anova test for employees component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	268.927	4	67.232	78.358	.000b
	Residual	191.336	223	.858		
	Total	460.263	227			

a Dependent Variable: BBVC

b. Predictors: (Constant), Employees with self-motivation, Employees with regular training, Employees with willingness to accept innovation, Employees with shared innovative value

Table 14 shows the linear regression's F-test, which has the null hypothesis $H3_0$ that there is no linear relationship between the dependent variables and independent variables at the component level (in other words R^2=0). The F-test show F value of 78.358 with highly significant P-value; thus, the study can assume that the null hypothesis $H3_0$ is rejected; hence, $H3_1$ is accepted, which means, at the components level, there is a significant linear relationship between the motivation and capability of the employees in SME architectural firms and BBVC. However, to determine the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the level of the indicator is presented in Table 15.

Table 15: Coefficient showing the linear regression estimates of all the indicators of the employees components on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.505	.177		2.844	.005
	Employees with regular training	.452	.090	.446	5.040	.000
	Employees with shared innovative value	.080	.094	.087	.842	.401
	Employees with willingness to accept innovation	.218	.098	.216	2.219	.027
	Employees with self-motivations	.525	.060	.524	8.697	.000

a. Dependent Variable: BBVC

Table 15 shows the multiple linear regression estimates of all the indicators, thus testing the four Sub-Hypotheses, H3a-H3d, including the intercept and the significance levels on the effect of each indicator on the IC of BBVC. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that there is a significant positive effect on BBVC when firms rely on the motivation and capability of employees with regular training, where there is a willingness to accept innovation and concerning employees' self-motivation. However, the capability of employees to share their innovative value with the firm does not significantly predict the success level of BIM adoption.

4.3.4 CONCLUSION ON THE ANALYSIS OF THE HC COMPONENTS

The objective of this section was to analyse the influence of HC on BBVC in SME architectural firms. A multiple regression analysis was conducted between the independent variables, consisting of various indicators under the three components of the HC aspect, and the dependent variable, namely BBVC. The analysis is a test of hypotheses, which is validated by the results in this section. The result indicates that all three components of the HC that are identified in the literature review have a significant correlation with BBVC. However, among the twelve indicators proposed under the three components, only ten were found to be useful predictors in the model. The rejected indicators are the ability to inspire others by the top manager and the motivation of shared innovative value by the employees, as shown in Figure 16.

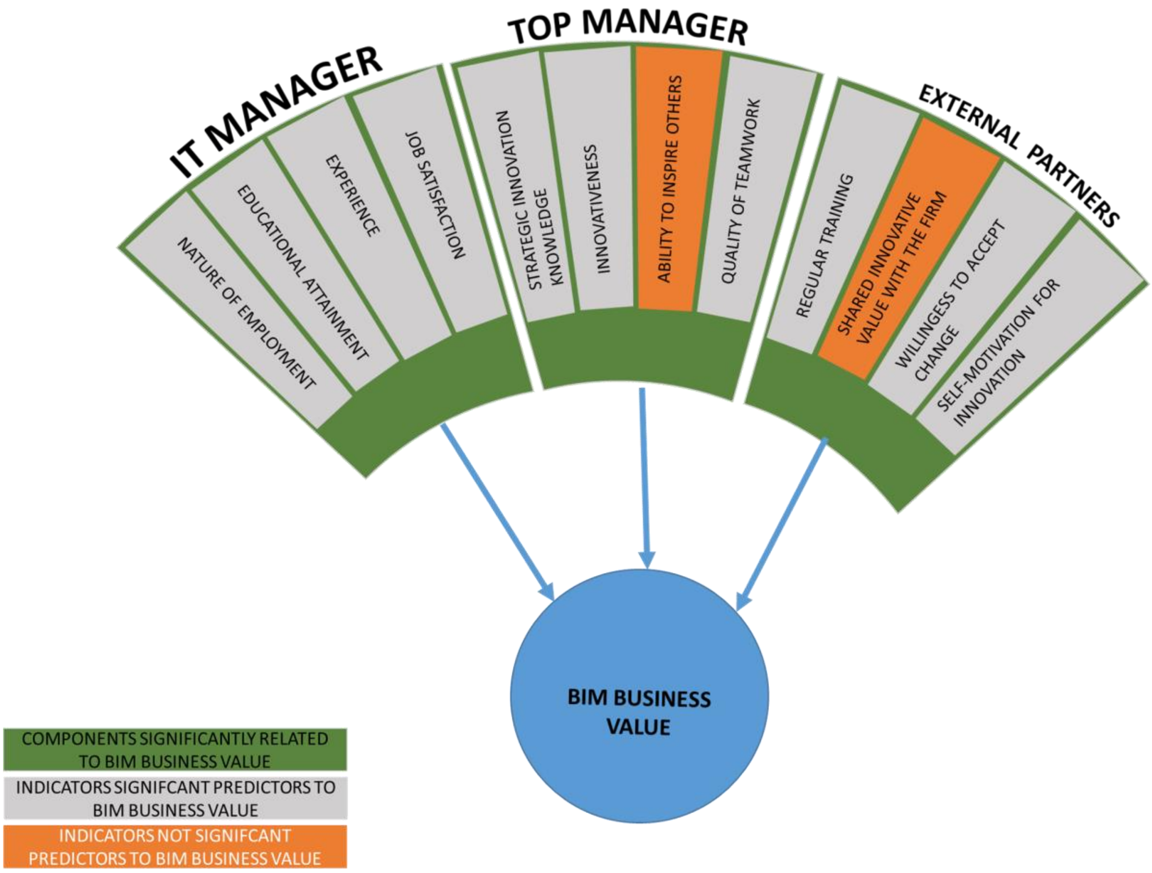


Figure 16: Evaluation for HC showing the critical components and indicators that predict BBVC

The development of the HC of SME architectural firms in the AEC industry is essential to the business process of BIM adoption; it also helps firms to evaluate their capability for innovation. The development of this capital involved the motivation and capability of all the human resource of the firm from the top management, the IT manager and the employees to all work simultaneously in creating BBVC. For example, while the IT manager's education and experiences add major value in the operational aspect of the BIM, there is a need for the firm to consider their job satisfaction, particularly concerning their work-life balance, which is believed to acknowledge and respond to the IT manager's working and personal needs and thus support their performance of their duties. Nevertheless, the top manager needs to ensure the continued understanding of the strategic need for planning in the BIM environment and encourage innovativeness and teamwork in settings and to implement strategic plans. Furthermore, education and training are identified as important elements of BIM implementation due to the process and technological changes they bring to an organisation. Hence, there is a need for regular training for general employees on the necessity of innovativeness as well as on the way BIM changes the processes of a firm. However, this should be done sensitively rather than as a directive as the need for positive self-motivation is critical for the success of the firm.

4.4 ANALYSIS OF THE RELATIONSHIP CAPITAL (RC) COMPONENTS

This section addresses the RC aspect of the analysis and involves the four components of the RC, as shown in Figure 15: Theoretical model for the BIM-based innovation showing the hypotheses formulated for analysis

1. The first component is the motivation and network resource resulting from the internal relationships in the firm, which comprise the following indicators.
    a. an efficient communication flow,
    b. confidence and trust,
    c. a participative culture,
    d. less uncertainty avoidance.
2. The second component involves the motivation and network resource resulting from external relations, which deal with the interoperability aspects of the firm. The different interoperability dimensions of the firm comprise the four external relationship indicators concerning the ability of the firm to interoperate with their external partners in carrying out activities. These indicators are the:
    a. technical interoperability,
    b. semantic interoperability,
    c. cultural interoperability,

    d. legal interoperability.

3. The third component deals with the motivation and network resources resulting from the environmental relationship of the firm, which has four interaction indicators, as follows:
    a. the client system,
    b. the technology marketplace,
    c. the competitiveness,
    d. the government/regulators.
4. The fourth component is the motivation and network resources resulting from the image and reputational aspect of the firm, for which there are four indicators, as follows:
    a. functionality (the outcome of BIM quality),
    b. social dimension (reputational gains),
    c. subjective dimensions (employee's external perception).

The analysis will test each indicator as an independent variable against the dependent variable of BBVC. Hence, each component is treated as an independent model of regression with the indicators as predictors. Finally, there is a discussion and conclusion of the findings at the end of the section.

4.4.1 THE INTERNAL RELATIONSHIP COMPONENT

This section presents the analysis of the relationship between the motivation and network resource of SME architectural firms through their internal relationships and BBVC. Table 16 lists the variables of the internal relationship component.

4.4.1.1 HYPOTHESES

$H4_1$: The motivation and network resources within the internal relationships of SME architectural firms have a significant correlation with BBVC.

$H4_0$: The motivation and network resources within the internal relationships of SME architectural firms have no significant correlation with BBVC.

4.4.1.1.1 Sub-Hypotheses

- *H6a: Firms that derive their motivation and network resource through the internal relationship characteristic of* ***effective communication flow*** *are likely to succeed in BBVC.*
- *H6b: Firms that derive their motivation and network resource through the internal relationship characteristic of* ***confidence and trust*** *are likely to succeed in BBVC.*
- *H6c: Firms that derive their motivation and network resource through the internal relationship characteristic of* ***participative culture*** *are likely to succeed in BBVC.*
- *H6d: Firms that derive their motivation and network resource through the internal relationship characteristic of* ***less uncertainty avoidance*** *are likely to succeed in BBVC.*

Table 16: Variables of the Internal Relationship component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The motivation and network resource of SME architectural firms through Internal relationship		BIM Business Value Creation (BBVC)
Indicators Level	1	Internal relationship of efficient communication flow	
	2	Internal relationship of confidence and trust,	
	3	Internal relationship of participative culture	
	4	Internal relationship of less uncertainty avoidance	

4.4.1.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the motivation and network resource, through the internal relationships of SME architectural firms and concerning innovation have a significant correlation with BBVC. This involved analysing the effect of four indicators of the internal relationship in predicting BBVC. Preliminary analysis shows that all assumptions are valid, and the potential indicator variables are accepted to carry out a multiple regression analysis.

Table 17: Model summary for the internal relationship component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.725[a]	.525	.517	.98978

a. Predictors: (Constant), Internal relationship of less uncertainty avoidance, Internal relationship of effective communication flow, Internal relationship of participative culture, Internal relationship of confidence and trust,

Table 17 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.517 with the $R^2 = 0.525$, which means that the linear regression explains 52.5% of the variance in the data.

Table 18: Anova test for the internal relationship component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	241.797	4	60.449	61.704	.000b
	Residual	218.466	223	.980		
	Total	460.263	227			

a. Dependent Variable: BIM adoption level

b. Predictors: (Constant), Internal relationship of less uncertainty avoidance, Internal relationship of effective communication flow, Internal relationship of participative culture, Internal relationship of confidence and trust

Table 18 shows the linear regression F-test which has the null hypothesis, $H4_0$ that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows F value of 61.704 with a highly significant P-value; thus the study can assume that the null hypothesis $H4_0$ is rejected. Hence, $H4_1$ is accepted, which means there is a significant linear relationship between the motivation and network through the internal relationships of SME architectural firms toward innovation and that this has a significant correlation with BBVC at the components level. However, to determine the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the level of the indicator is presented in Table 19.

Table 19: Coefficient showing the linear regression estimates of all the indicators of the internal relationship components on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.659	.177		3.729	.000
	Internal relationship of effectient communication flow	.235	.078	.248	3.000	.003
	Internal relationship of confidence and trust,	.049	.089	.050	.553	.581
	Internal relationship of participative culture	.307	.089	.296	3.467	.001
	Internal relationship of less uncertainty avoidance	.196	.075	.205	2.601	.010

a. Dependent Variable: BBVC

Table 19 shows the multiple linear regression estimates of all the indicators, thus testing the four Sub-Hypotheses, H4a-H4d, including the intercept and the significance levels on the effect of each IC indicator on the success level of BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows there is the significant positive effect on BBVC when firms have internal relationships demonstrating an efficient communication flow, a participative culture and with less uncertainty avoidance; however an indicator of confidence and trust in the internal relationship was found to be an insignificant predictor of the success level of BIM adoption.

4.4.2 THE EXTERNAL RELATIONSHIP COMPONENT

This section presents the analysis of the relationship between the motivation and network resource of SME architectural firms through external relationships and BBVC. Table 20 lists the variables of the external relationship component.

4.4.2.1 HYPOTHESES

$H5_1$: The motivation and network resources of SME architectural firms, through external interoperability, have a significant correlation with BBVC.

$H5_0$: The motivation and network resources of SME architectural firms, through external interoperability, have no significant correlation with BBVC.

4.4.2.1.1 Sub-Hypotheses

- *H5a: Firms that derive their motivation and network resource as a result of their **technical ability** to interoperate with external partners are likely to succeed in BBVC.*
- *H5b: Firms that derive their motivation and network resource as a result of their **semantic ability** to interoperate with external partners are likely to succeed in BBVC.*
- *H5c: Firms that derive their motivation and network resource as a result of their **cultural ability** to interoperate with external partners are likely to succeed in BBVC.*
- *H5d: Firms that derive their motivation and network resource as a result of their **legal ability** to interoperate with external partners are likely to succeed in BBVC.*

Table 20: Variables of the external relationship component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The motivation and network resource of SME architectural firms through external relationships		BIM Business Value Creation (BBVC)
Indicators Level	1	Technical interoperability	
	2	Semantic interoperability	
	3	Cultural interoperability	
	4	Legal interoperability	

4.4.2.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the motivation and network resources for innovation through the external relationship of SME architectural firms have a significant correlation with BBVC. This involved analysing the effect of the four indicators of the external relationship in predicting the BBVC. Preliminary analysis shows that all assumptions are valid and the potential variables of the indicators are accepted to carry out the multiple regression analysis.

Table 21: Model summary for the external relationship component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.655a	.429	.419	1.08548

a. Predictors: (Constant), Legal interoperability, Technical interoperability, Cultural interoperability, Semantic interoperability

Table 21 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.419 with the $R^2 = 0.429$, which means that the linear regression explains 42.9% of the variance in the data.

Table 22: Anova test for the external relationship component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	197.507	4	49.377	41.906	.000b
	Residual	262.756	223	1.178		
	Total	460.263	227			

a. Dependent Variable: BBVC

b. Predictors: (Constant), Legal interoperability, Technical interoperability, Cultural interoperability, Semantic interoperability

Table 22 shows the linear regression's F-test, which has the null hypothesis, $H5_0$ namely that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows F value of 41.906 with a highly significant P-value; thus the study can assume that the null hypothesis $H5_0$ is rejected. Hence, $H5_1$ is accepted which means there is a significant linear relationship between the motivation and network of the SME architectural firm's external relationships regarding innovation as this has a significant correlation with BBVC at the components level. However, to understand the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis at the indicator level is presented in the Table 23.

Table 23: Coefficient showing the linear regression estimates of all the indicators of the external relationship components on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.006	.202		4.975	.000
	Technical interoperability	.336	.105	.334	3.214	.002
	Semantic interoperability	.236	.107	.253	2.205	.028
	Cultural interoperability	-.327	.112	-.323	-2.914	.004
	Legal interoperability	.439	.072	.440	6.125	.000

a. Dependent Variable: BBVC

Table 23 shows the multiple linear regression estimates of all the indicators, thus testing the four sub-hypotheses, H5a-H5d, including the intercept and the significance levels on the effect of each indicator for the IC and success level of BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that firms that derive their motivation and network resource as a result of their technical, semantic and legal abilities to interoperate with external partners are likely to succeed in BBVC. Although the element of cultural interoperability is also significant in predicting the BBVC, this effect is shown to be negative in nature. Hence, the less interoperable the SME architectural firms can be regarding their culture, the more positive a value it will have for the success level in terms of BIM adoption.

4.4.3 THE ENVIRONMENTAL RELATIONSHIP COMPONENT

This section presents the analysis of the relationship between motivation and network resource of SME architectural firms through their environmental relationship and BBVC. Figure 24 lists the variables of the environmental relationship component.

4.4.3.1 HYPOTHESES

$H6_1$: The motivation and network resources of SME architectural firms, through environmental relationships, have a significant correlation with BBVC.

$H6_0$: The motivation and network resources of SME architectural firms, through environmental relationships, have no significant correlation with BBVC.

4.4.3.1.1 Sub-Hypotheses

- *H6a: Firms that derive their capability and network resource through motivation from **the client system** in the innovative environment are likely to succeed in BBVC.*
- *H6b: Firms that derive their capability and network resource through motivation from **technology market dynamism** in the innovative environment are likely to succeed in BBVC.*
- *H6c: Firms that derive their capability and network resource through motivation from **competitiveness** in the innovative environment are likely to succeed in BBVC.*
- *H8c: Firms that derive their capability and network resource through motivation from **government and regulatory systems** in the innovative environment are likely to succeed in BBVC.*

Table 24: Variables of the environment relationship component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The motivation and network resource of SME architectural firms through the environmental relationship		BIM Business Value Creation (BBVC)
Indicators Level	1	The client system in the innovative environment	
	2	The technology market dynamism in the innovative environment	
	3	The competitiveness in the innovative environment	
	4	The government and regulatory system in the innovative environment	

4.4.3.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the motivation and network resources, through the environmental relationship of SME architectural firms toward innovation, have a significant correlation with BBVC. This involved analysing the effect of four environmental relationship indicators in predicting BBVC. Preliminary analysis shows that all assumptions are valid and the potential indicator variables are accepted to carry out the multiple regression analysis.

Table 25: Model summary for the environmental relationship component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.726[a]	.526	.518	.98870

a. Predictors: (Constant), The government and regulatory system in the innovative environment, The client system in the innovative environment, The technology marketplace in the innovative environment, The competitiveness in the innovative environment

Table 25 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.518 with the $R^2 = 0.526$, which means that the linear regression explains 52.6% of the variance in the data.

Table 26: Anova test for the environmental relationship component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	242.273	4	60.568	61.960	.000[b]
	Residual	217.991	223	.978		
	Total	460.263	227			

a. Dependent Variable: BBVC

b. Predictors: (Constant), The government and regulatory system in the innovative environment, The client system in the innovative environment, The technology marketplace in the innovative environment, The competitiveness in the innovative environment

Table 26 shows the linear regression's F-test, which has the null hypothesis, $H6_0$ that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows a highly significant P-value; thus the study can assume that the null hypothesis $H6_0$ is rejected. Hence, $H6_1$ is accepted, which means there is a significant linear relationship between the motivation and network through environmental relationship of SME architectural firms toward innovation and this has a significant correlation with BBVC at the components level. However, to understand the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the indicator level is presented in Table 27.

Table 27: Coefficient showing the linear regression estimates of all the environmental relationship indicators of the components on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.798	.172		4.628	.000
	The client system in the innovative environment	.602	.065	.598	9.257	.000
	The technology marketplace in the innovative environment	-.164	.088	-.175	-1.856	.065
	The competitiveness in the innovative environment	.214	.093	.223	2.288	.023
	The government and regulatory system in the innovative environment	.112	.085	.113	1.319	.189

a. Dependent Variable: BBVC

Table 27 shows the multiple linear regression estimates of all the indicators, thus testing the four sub-hypotheses, H6a-H6d, including the intercept and the significance levels on the effect of each IC indicator on the success of BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows firms that derive their capability and network resource through motivation from the client system and competitiveness in the innovative environment are likely to succeed in BBVC. Meanwhile the technology and the government and regulatory system indicators have not been a significant predictor for success in BIM adoption.

4.4.4 THE IMAGE AND REPUTATION COMPONENT

This section presents the analysis of the relationship between motivation and network resource of SME architectural firms through their image and reputation and BBVC. Table 28 lists the variables of the image and reputation component.

4.4.4.1 HYPOTHESES

$H7_1$: The motivation and network resources, through the reputation and image of SME architectural firms, have a significant correlation with BBVC.

$H7_0$: The motivation and network resources, through the reputation and image of SME architectural firms, have no significant correlation with BBVC.

4.4.4.1.1 Sub-Hypotheses

- *H7a: Firms that derive their motivation and network resource as a result of the **functional reputation** of the use of technology are likely to succeed in BBVC.*
- *H7b: Firms that derive their motivation and network resource as a result of the **social reputation** of the use of technology are likely to succeed in BBVC.*
- *H7c: Firms that derive their motivation and network resource as a result of **employees' subjective reputation** concerning the use of technology are likely to succeed in BBVC.*

Table 28: Variables of the image and reputation component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The motivation and network resource through image and reputation.		BIM Business Value Creation (BBVC)
Indicators Level	1	Functionality (outcome of BIM quality)	
	2	Social dimension (reputational gains)	
	3	Internal dimensions (employees perception)	

4.4.4.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the motivation and network resources of SME architectural firms through their image and reputation concerning innovation have a significant correlation with BBVC. This involved analysing the effect of the three indicators of image and reputation in predicting the BBVC. Preliminary analysis shows that all assumptions are valid and the potential indicator variables are accepted to carry out the multiple regression analysis.

Table 29: Model summary for the image and relationship component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.653[a]	.427	.419	1.08541

a. Predictors: (Constant), Internal dimensions (employees perception), Functionality (outcome of BIM quality), Social dimension (reputational gains)

Table 29 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.419 with the $R^2 = 0.427$, which means that the linear regression explains 42.7% of the variance in the data.

Table 30: Anova test for the image and reputation component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	196.368	3	65.456	55.560	.000[b]
	Residual	263.895	224	1.178		
	Total	460.263	227			

a. Dependent Variable: BBVC

b. Predictors: (Constant), Internal dimensions (employees perception), Functionality (outcome of BIM quality), Social dimension (reputational gains)

Table 30 shows the linear regression's F-test, which has the null hypothesis, $H7_0$, that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows F value of 55.56 with a highly significant P-value; thus the study can assume that the null hypothesis $H7_0$ is rejected. Hence, $H7_1$ is accepted, which means there is a significant linear relationship between the motivation and network through the image and reputation of SME architectural firms toward innovation, which has a significant correlation with BBVC at the components level. However, to determine the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the indicator analysis is presented in Table 31.

Table 31: Coefficient showing the linear regression estimates of all the image and reputation indicators component on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.746	.206		3.616	.000
	Functionality (outcome of BIM quality)	.464	.085	.448	5.433	.000
	Social dimension (reputational gains)	.074	.088	.079	.837	.404
	Internal dimensions (employees perception)	.188	.078	.186	2.407	.017

a. Dependent Variable: BBVC

Table 31 is the coefficient table showing the linear regression estimates of all the image and reputation indicators component on BBVC shows. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that firms that derive their motivation and network resource as a result of their functional (outcome of BIM quality) and subjective internal (employees perception) reputation in the use of technology are likely to succeed in BBVC. However, the social dimension indicator (reputational gains) is not found to be a significant predictor of BBVC.

4.4.5 CONCLUSION ON ANALYSIS OF RC COMPONENTS

The objective of this section is to analyse the influence of RC on BBVC creation in SME architectural firms. A multiple regression analysis was conducted between the independent variables, consisting of various indicators under the four RC components and the dependent variable of BBVC creation. The analysis is a test of the hypotheses, which were validated by the results in this section. The results indicated that all four RC components proposed by the theoretical model showed a positive and significant impact on BBVC creation. However, of the fifteen indicators under these four components, eleven were accepted, and four were rejected. The rejected indicators were; confidence and trust within the internal relationship, the technology marketplace and government regulatory systems under the environmental relationship component, and that of social reputation under the image and reputation component. Figure 17 shows the result of the analysis of the effect of the different indicators on the BBVC. Indicators in reds are those rejected while those in ash are accepted.

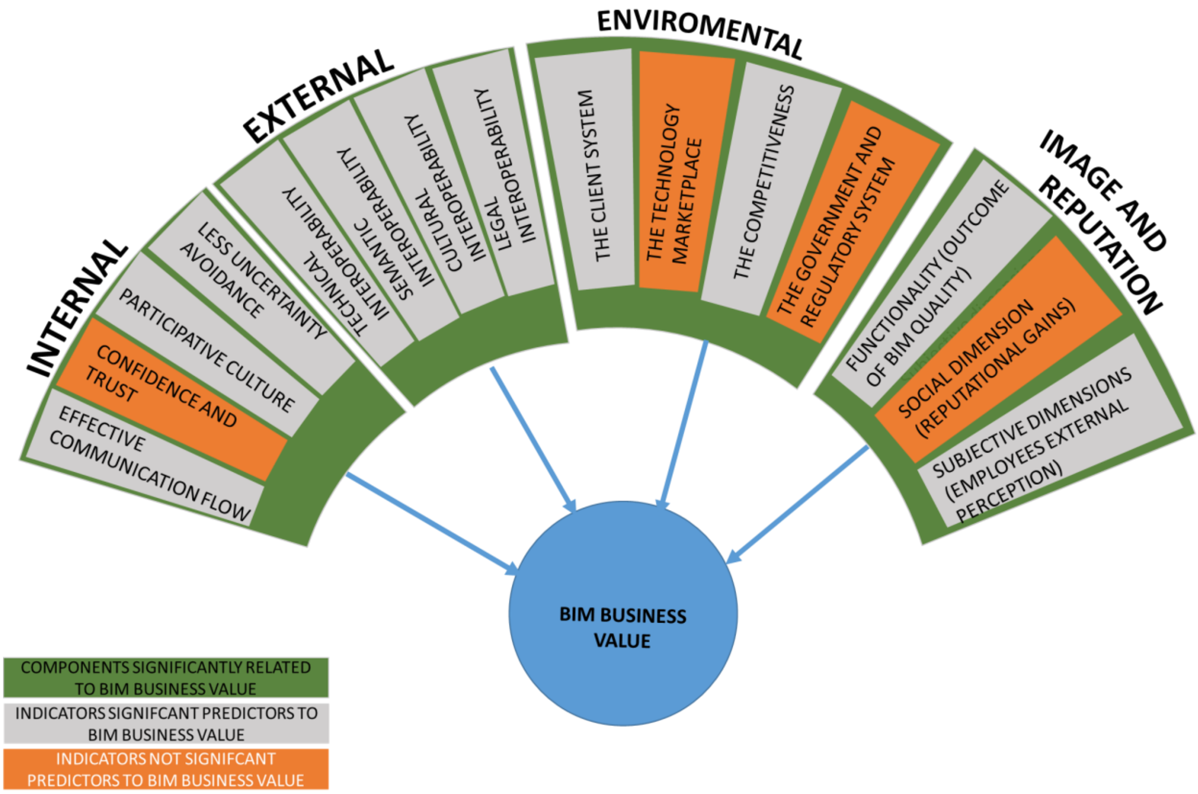


Figure 17: Evaluation for RC showing the critical components and indicators that predict BBVC

In conclusion, the findings for this section indicate that the development of motivation and networks resulting from RC have a significant impact on BBVC in SME architectural firms. Thus, the better SME architectural firms manage and nurture their RC network resource, the more success those firms can experience in terms of BBVC. This network resource is formed through specific critical aspects of the interaction between the firm's internal and external relationships, environment, and image and reputations. For example, within the internal hierarchy, the effective communication flow, encouragement of a participative culture in the innovation process, and less uncertainty avoidance is critical to the development of the network resource.

Another critical aspect in the development of network resources for the BIM adoption process is the aspect of firm interoperability in efficiently operating within the BIM environment. These include technical, semantic, cultural and legal interoperability. Although government and regulatory systems have been proven to play a crucial role in the environmental influence of the BIM adoption process, because there is no clear intervention policy on BIM in Nigeria, only the client system and the competitive environment are critical to BBVC. Additionally, image and reputation, particularly through the outcome quality of BIM and employees' perceptions of their competitive advantage, are found to be critical in BIM Business Value Creation.

4.5 ANALYSIS OF STRUCTURE CAPITAL (SC) COMPONENTS

This part deals with the SC analysis, and involves an analysis of the three SC components, as shown in Figure 15: Theoretical model for the BIM-based innovation showing the hypotheses formulated for analysis

1. The first component is the capability and support of the organisational system structure of the firm, which comprises the following four indicators:
    a. flexible administrative systems for innovation,
    b. effective knowledge management systems,
    c. flexible policy systems for innovation,
    d. systems for internal experimentation culture.
2. The second component involved the capability and support of the organisational infrastructures and facilities of the firm, which involved the following five indicators;
    a. the availability of digital hardware facilities,
    b. the availability of digital software facilities,
    c. the availability of network facilities,
    d. specific office space for ICT units,
    e. maintenance and upgrade facilities for technology.

3. The third component deals with the capability and support of the organisational process and schemes, which have the following four indicators;
    a. reward and incentive schemes,
    b. in-house training schemes,
    c. strategic innovation management schemes,
    d. research and development schemes.

The analysis will test each indicator as an independent variable against the dependent variable of BBVC. Hence, each component is treated as an independent model of regression with the indicators as predictors. Finally, there is a discussion on, and summary of, the findings at the end of the SC section.

4.5.1 THE SYSTEM STRUCTURE COMPONENT

This section presents the analysis of the relationship between the capability and support of the SME architectural firm's organisational system structure and BBVC. Table 32 lists the variables of the organisational system structure component.

4.5.1.1 HYPOTHESES

$H8_0$: The capability and support of SME architectural firms, through the organisational system structure, have a significant correlation with BBVC.

$H8_1$: The capability and support of SME architectural firms, through the organisational system structure, have no significant correlation with BBVC.

4.5.1.1.1 Sub-Hypotheses

- *H8a: Firms that develop their capability and support through **a flexible administrative system for innovation** are likely to succeed in BBVC.*
- *H8b: Firms that develop their capability and support through **an efficient knowledge management system** are likely to succeed in BBVC.*
- *H8c: Firms that develop their capability and support through **a flexible policy system for innovation** are likely to succeed in BBVC.*
- *H8d: Firms that develop their capability and support through **a system enabling an experimentation culture** are likely to succeed in BBVC.*

Table 32: Variables of organisational system structure component

<table>
<tr><td colspan="3">INDEPENDENT VARIABLES</td><td>DEPENDENT VARIABLES</td></tr>
<tr><td>Component Level</td><td colspan="2">The capability and support of the organisational system structure of SME architectural firms.</td><td rowspan="5">BIM Business Value Creation (BBVC)</td></tr>
<tr><td rowspan="4">Indicators Level</td><td>1</td><td>Flexible administrative systems for innovation</td></tr>
<tr><td>2</td><td>Efficient knowledge management systems</td></tr>
<tr><td>3</td><td>Flexible policy systems for innovation</td></tr>
<tr><td>4</td><td>Systems enabling an experimentation culture</td></tr>
</table>

4.5.1.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the capability and support for innovation within SME architectural firms, through their organisational system structure, have a significant correlation with BBVC. This involved analysing the effect of four indicators within the organisational system structure in predicting BBVC. The preliminary analysis shows that all assumptions are valid and the potential variables of the indicators are accepted to carry out the multiple regression analysis.

Table 33: Model summary for the organisational system structure component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.679[a]	.461	.451	1.05476

a. Predictors: (Constant), System for experimentation culture, Flexible policy system for innovation, Flexible administrative system for innovation, Efficient knowledge management system

Table 33 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.451 with the $R^2 = 0.461$, which means that the linear regression explains 46.1% of the variance in the data.

Table 34: Anova test for the organisational system structure component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	212.172	4	53.043	47.678	.000[b]
	Residual	248.092	223	1.113		
	Total	460.263	227			

a. Dependent Variable: BBVC

b. Predictors: (Constant), System for experimentation culture, Flexible policy system for innovation, Flexible administrative system for innovation, Effective knowledge management system

Table 34 shows the linear regression's F-test, which has the null hypothesis, $H8_0$, that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows F value of 47.687 with a highly significant P-value; thus, the study can assume that the null hypothesis $H8_0$ is rejected. Hence, $H8_1$ is accepted. This means that, through their organisational system structure, there is a significant linear relationship at the components level between the capability and support of SME architectural firms and BBVC. However, to understand the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the indicator level is presented in Table 35.

Table 35: Coefficient showing the linear regression estimates of all the indicators of the system structure components of BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.647	.204		3.174	.002
	Flexible administrative system for innovation	-.043	.083	-.046	-.516	.607
	Effecient knowledge management system	.086	.100	.084	.865	.388
	Flexible policy system for innovation	.446	.070	.446	6.385	.000
	System for experimentation culture	.279	.083	.271	3.382	.001

a. Dependent Variable: BBVC

Table 35 shows the multiple linear regression estimates of all the indicators, thus testing the four Sub-Hypotheses, H8a-H8d, including the intercept and significance levels of the effect of each indicator on the IC and success level of BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that firms that develop their capability and support as a result of flexible policy systems and an experimentation culture that supports innovation are likely to succeed in BBVC while the flexible administrative systems and knowledge management systems are not significant predictors of the success level of BIM adoption.

4.5.2 THE ORGANISATIONAL INFRASTRUCTURES AND FACILITIES COMPONENT

This section presents the analysis of the relationship between capability and support of SME architectural firms through their organisational facilities and infrastructure and BBVC. Table 36 lists the variables of the organisational infrastructures and facilities component.

4.5.2.1 HYPOTHESES

H9$_0$: The capability and support of SME architectural firms' organisational infrastructures and facilities have a significant correlation with BBVC success.

H9$_1$: The capability and support of SME architectural firms' organisational infrastructures and facilities have no significant correlation with BBVC success.

4.5.2.1.1 Sub-Hypotheses

- *H9a: Firms that develop their capability and support through the **availability of digital hardware facilities** are likely to succeed in BBVC.*
- *H9b: Firms that develop their capability and support through the **availability of digital software facilities** are likely to succeed in BBVC.*
- *H9c: Firms that develop their capability and support through the **availability of network facilities** are likely to succeed in BBVC.*
- *H9d: Firms that develop their capability and support through the **availability of specific office space for ICT units** are likely to succeed in BBVC.*
- *H9e: Firms that develop their capability and support through the **availability of maintenance and upgrade facilities for technology** are likely to succeed in BBVC.*

Table 36: Variables of the organisational infrastructures and facilities component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The capability and support of organisational infrastructures and facilities of SME architectural firms.		BIM Business Value Creation (BBVC)
Indicators Level	1	Availability of digital hardware facilities	
	2	Availability of digital software facilities	
	3	Availability of network facilities	
	4	Availability of specific office space for ICT units	
	5	Availability of maintenance and upgrade facilities for technology	

4.5.2.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the capability and support of SME architectural firms' organisational infrastructure and facilities for innovation have a significant correlation with BBVC. This involved analysing the effect of five organisational infrastructure facility indicators in predicting the BBVC. Preliminary analysis shows that all assumptions are valid and the potential variables of the indicators are accepted to carry out the multiple regression analysis.

Table 37: Model summary for organisational infrastructure and facilities component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.759[a]	.576	.566	.93811

a. Predictors: (Constant), Availability of maintenance and upgrade facilities for technology, Availability of digital hardware facilities, Availability of network facilities, Availability of specific office space for ICT unit, Availability of digital software facilities

Table 37 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.566 with the $R^2 = 0.576$, which means that the linear regression explains 57.6% of the variance in the data.

Table 38: Anova test for the organisational infrastructure and facilities component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	264.891	5	52.978	60.199	.000[b]
	Residual	195.372	222	.880		
	Total	460.263	227			

a. Dependent Variable: BIM adoption level

b. Predictors: (Constant), Availability of maintenance and upgrade facilities for technology, Availability of digital hardware facilities, Availability of network facilities, Availability of specific office space for ICT units, Availability of digital software facilities

Table 38 shows the linear regression's F-test, which has the null hypothesis, $H9_0$, that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows F value of 60.199 with a highly significant P-value; thus the study can assume that the null hypothesis, $H9_0$, is rejected. Hence, $H9_1$ is accepted which means there is a significant linear relationship between the capability and support of organisational infrastructure and facilities of SME architectural firms with BBVC at the components level. However, to understand the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the indicator level is presented in Table 39.

Table 39: Coefficient showing the linear regression estimates of the indicators of the organisational infrastructure and facilities components of BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.791	.179		4.405	.000
	Availability of digital Hardware facilities	.261	.093	.280	2.793	.006
	Availability of Digital Software facilities	.236	.098	.234	2.410	.017
	Availability of network facilities	.246	.081	.244	3.023	.003
	Availability of specific office space for ICT unit	.097	.093	.094	1.044	.298
	Availability of maintenance and upgrade facilities for technology.	.407	.082	.435	4.981	.000

a. Dependent Variable: BIM adoption level

Table 39 shows the multiple linear regression estimates of all the indicators, thus testing the four sub-hypotheses, H9a-H9e, including the intercept and the significance levels of the effect of each indicator of the IC and the success level of BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that, to succeed in BBVC, firms develop their capability and support as a result of the availability of digital hardware facilities, digital software facilities, and network facilities and also maintain and upgrade such regularly to support technology. However, the availability of specific office space for ICT unit is not found to have any significant correlation with BBVC.

4.5.3 THE ORGANISATIONAL PROCESS AND SCHEME COMPONENT

This section presents the analysis of the relationship between the capability and support of the organisational process and schemes of SME architectural firms and BBVC. Table 40 lists the variables of the organisational process and scheme component.

4.5.3.1 HYPOTHESES

$H10_0$: The capability and support of organisational process and schemes of SME architectural firms have a significant correlation with BBVC.

$H10_1$: The capability and support of organisational process and schemes of SME architectural firms have no significant correlation with BBVC.

4.5.3.1.1 Sub-Hypotheses

- *H10a: Firms that develop their capability and support through* ***reward and incentive schemes for innovation*** *are likely to succeed in BBVC.*
- *H10b: Firms that develop their capability and support through* ***in-house training schemes for innovation*** *are likely to succeed in BBVC.*
- *H10c: Firms that develop their capability and support through* ***strategic innovation management schemes*** *are likely to succeed in BBVC.*
- *H10d: Firms that develop their capability and support through* ***research and development schemes*** *are likely to succeed in BBVC.*

Table 40: Variables of the organisational process and scheme component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The capability and support of organisational process and schemes of SME architectural firms.		BIM Business Value Creation (BBVC)
Indicators Level	1	Reward and incentive schemes for innovation	
	2	In-house training schemes for innovation	
	3	Strategic innovation management schemes	
	4	Research and development schemes	

4.5.3.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the capability and support of organisational process and schemes of SME architectural firms for innovation have a significant correlation with BBVC. This involved analysing the effect of four organisational process and scheme indicators in predicting BBVC. Preliminary analysis shows that all assumptions are valid and the potential variables of the indicators are accepted to carry out the multiple regression analysis.

Table 41: Model summary for the organisational process and scheme component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.791[a]	.626	.620	.87817

Predictors: (Constant), Research and development schemes, In-house training schemes for innovation, Reward and incentive schemes for innovation, Strategic innovation management schemes

Table 41 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.620 with the $R^2 = 0.626$, which means that the linear regression explains 62.6% of the variance in the data.

Table 42: Anova test for the organisational and process scheme component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	288.289	4	72.072	93.456	.000[b]
	Residual	171.975	223	.771		
	Total	460.263	227			

a. Dependent Variable: BIM adoption level

b. Predictors: (Constant), Research and development schemes, In-house training schemes for innovation, Reward and incentive schemes for innovation, Strategic innovation management schemes

Table 42 shows the linear regression's F-test, which has the null hypothesis, $H10_0$, that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows F value of 93.456 with a highly significant P-value; thus, the study can assume that the null hypothesis $H10_0$ is rejected. Hence, $H10_1$ is accepted, which means there is a significant linear relationship between SME architectural firms' capability and support of organisational process and schemes, and BBVC at the components level. However, to determine the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the level of the indicator is presented in the next table.

Table 43: Coefficient showing the linear regression estimates of all the indicators of the organisational and process scheme component on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.165	.174		.951	.343
	Reward and incentive schemes for innovation	.380	.084	.371	4.507	.000
	In-house training schemes for innovation	-.033	.077	-.037	-.436	.663
	Strategic innovation management schemes	.351	.089	.331	3.951	.000
	Research and development schemes	.201	.079	.213	2.548	.012

a. Dependent Variable: BIM adoption level

Table 43 shows the multiple linear regression estimates of all the indicators, thus testing the four sub-hypotheses, H10a-H10d, including the intercept and significance levels on the effect of each IC indicator on the success of BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that firms that develop their capability and support as a result of their rewards and incentives, strategic innovation management schemes, and research and development are likely to succeed in BBVC, while in-house training schemes were not found to be a significant predictor of BBVC.

4.5.4 CONCLUSION ON THE ANALYSIS OF THE STRUCTURE CAPITAL COMPONENTS

The objective of this section was to analyse the influence of SC on BBVC in SME architectural firms. A multiple regression analysis was conducted between the independent variables, consisting of various indicators under the three SC components, and the dependent variable of BBVC. The analysis is a test of the hypotheses, one of which was validated by the results in this section.

The result indicated that all the three components of the SC that were identified in the literature review have a significant correlation with BBVC. However, some indicators were not found to be useful in predicting BBVC, which include: flexible administrative systems and knowledge management system structures. In comparison, the availability of specific office infrastructures for BIM and the availability of in-house training were found to be useful. Figure 18 shows the result of the analysis of the effect of the different indicators on the BBVC. Indicators in red are those rejected while those in ash are accepted.

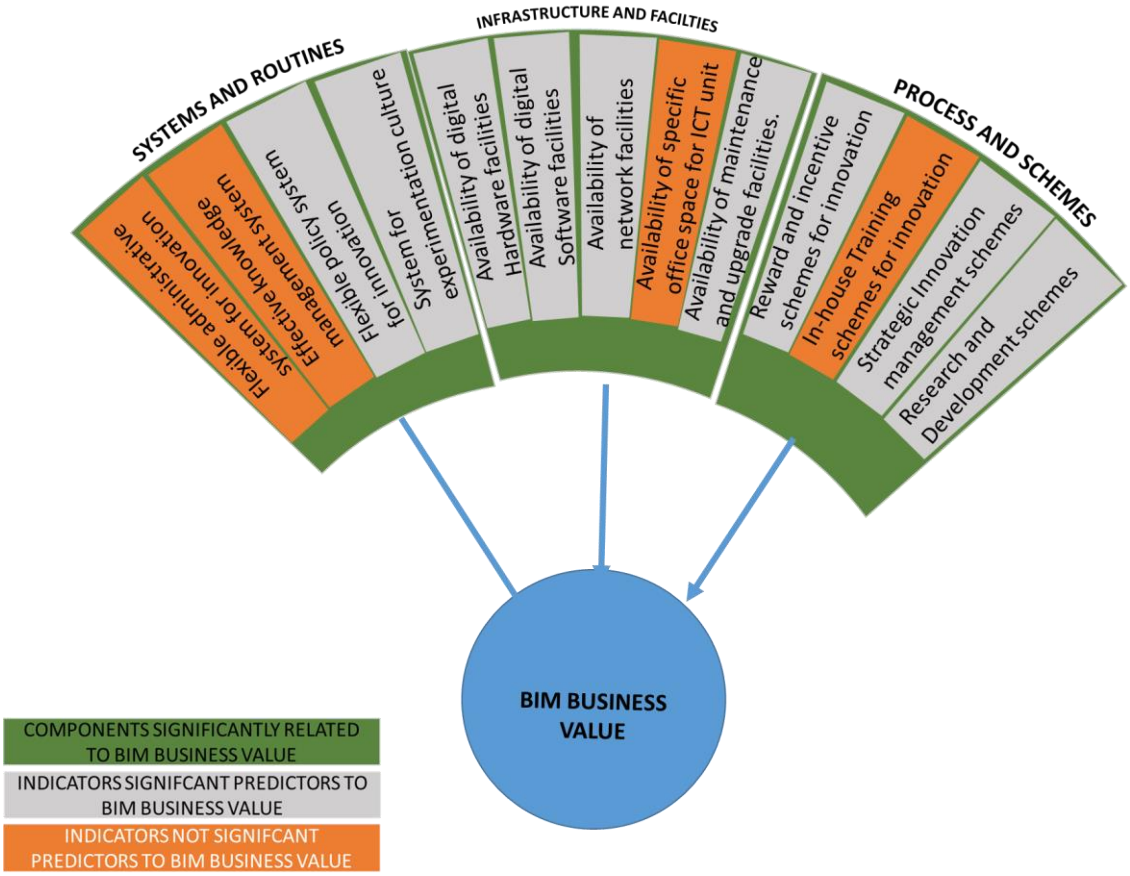


Figure 18: Evaluation for SC showing the critical components and indicators that predict BBVC

The development of the SC of SME architectural firms in the AEC industry is essential for the business process of BIM adoption, and helps firms to evaluate their capability for innovation. This development involved three critical foci in terms of system structure, infrastructure and facilities, and process and scheme. The BIM adoption process involves restructuring the policy system of a firm and that should enable an experimentation culture. This is enabled by a fitting infrastructure and facilities for leveraging technology, which include: software, hardware, networks and the regular maintenance and upgrade of such facilities. The process also involved the formalisation of incentives and rewards, strategic innovation management, and adequate research and development.

The rejection of a flexible administration system and effective knowledge management system under the system and routines of the firms may be attributed due to conservative nature of the architectural profession where the profession is more valued than any competitive advantage of innovation. This may also be consistent with the reason why availability of specific office for ICT unit was also found to be rejected. However, in the case of in-house training is a peculiar case which is often regarded as an important organ of every professional organisation.

4.6 THE ANALYSIS OF KNOWLEDGE (KC) COMPONENTS

This section deals with the KC aspect of the analysis. It involved analysing the three components of KC, as shown in Figure 10. The first component is the knowledge exploration capacity of the SME architectural firms, which comprises three indicators: internal inventive capacity, network absorptive capacity, and University and Research Institutes' (URIs) absorptive capacity. The second component involved the knowledge retention capacity of the SME architectural firms with three indicators as internal transformative capacity, connective capacity (alliance) with external partners and connective capacity (alliance) with URIs. Lastly, the third component deals with the knowledge exploitation capacity of SME architectural firms with the two indicators of internal exploitation capacity and external exploitation capacity. The analysis will test each indicator as an independent variable against the dependent variable of BBVC. Hence, each component is treated as an independent model of regression with the indicators as predictors. Finally, there is a discussion and summary of the findings at the end of the section.

4.6.1 KNOWLEDGE EXPLORATION CAPACITY

This section presents the analysis of the relationship between the knowledge exploration capacity of SME architectural firms and BBVC. Table 44 lists the variable of the knowledge exploration capacity component.

4.6.1.1 HYPOTHESES

$H11_1$: The knowledge exploration capacity of SME architectural firms has a significant correlation with BBVC.

$H11_0$: The knowledge exploration capacity of SME architectural firms has no significant correlation with BBVC.

4.6.1.1.1 Sub-Hypotheses

- *H11a: Firms that have an* ***internal inventive capacity*** *to generate and integrate new knowledge are likely to succeed in BBVC*
- *H11b: Firms that have a* ***network absorptive capacity*** *to acquire and assimilate new knowledge are likely to succeed in BBVC*
- *H11c: Firms that have a* ***URI absorptive capacity*** *to acquire and assimilate new knowledge are like to succeed in BIM adoption*

Table 44: Variable of the knowledge exploration capacity component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The knowledge exploration capacity		BIM Business Value Creation (BBVC)
Indicators Level	1	Internal inventive capacity	
	2	Network absorptive capacity	
	3	URI absorptive capacity	

4.6.1.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the knowledge exploration capacity has a significant correlation with BBVC. This involved analysing the effect of three indicators of the knowledge exploration capacity in predicting BBVC. Preliminary analysis shows that all assumptions are valid and the potential indicator variables are accepted to carry out the multiple regression analysis.

Table 45: Model summary for the knowledge exploration capacity component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.715[a]	.512	.505	1.00148

a. Predictors: (Constant), URI absorptive capacity, Business network absorptive capacity, Internal inventive capacity

Table 45 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.505 with the $R^2 = 0.512$, which means that the linear regression explains 51.2% of the variance in the data.

Table 46: Anova test for the knowledge exploration capacity component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	235.598	3	78.533	78.300	.000b
	Residual	224.665	224	1.003		
	Total	460.263	227			

a. Dependent Variable: BBVC

b. Predictors: (Constant), URI absorptive capacity, Business network absorptive capacity, Internal inventive capacity

Table 46 shows the linear regression's F-test, which has the null hypothesis, $H11_0$, that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows a highly significant P-value; thus the study can assume that the null hypothesis, $H11_0$ is rejected. Hence, $H11_1$ is accepted, which means there is a significant linear relationship between the knowledge exploration capacity of SME architectural firms with BBVC at the components level. However, to understand the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the indicator analysis is presented in Table 47.

Table 47: Coefficient showing the linear regression estimates of all the indicators of the knowledge exploration capacity components of BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.814	.185		4.403	.000
	Internal inventive capacity	.159	.093	.175	1.706	.089
	Business Network absorptive capacity	.533	.072	.525	7.414	.000
	Uris absorptive capacity	.065	.105	.063	.617	.538

a. Dependent Variable: BBVC

Table 47 shows the multiple linear regression estimates of all the indicators, thus testing the four sub-hypotheses, H11a-H11c, including the intercept and significance levels on the effect of each IC indicator on the success of a BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that firms that have business network absorptive capacity to acquire and assimilate new knowledge are likely to succeed in BBVC, while the firm's internal inventive capacity to generate and integrate new knowledge, and URI's absorptive capacity to acquire and assimilate new knowledge was not found to have a significant effect on BBVC.

4.6.2 KNOWLEDGE RETENTION CAPACITY

This section presents the analysis of the relationship between the knowledge retention capacity of SME architectural firms and BBVC. Table 48 lists the variables for the knowledge retention capacity component.

4.6.2.1 HYPOTHESES

$H12_1$: The knowledge retention capacities of SME architectural firms have a significant correlation with BBVC.

$H12_0$: The knowledge retention capacities of SME architectural firms have no significant correlation with BBVC.

4.6.2.1.1 Sub-Hypotheses

- *H12a: Firms that have the* ***transformative capacity to internally maintain and reactivate knowledge*** *for continued use are likely to succeed in BBVC.*
- *H12b: Firms that have* ***the connective capacity through alliance and cooperation with external partners to maintain and reactivate knowledge*** *for continued use are likely to succeed in BBVC.*
- *H12c: Firms that have the* ***connective capacity through alliance and cooperation with URIs to maintain and reactivate knowledge*** *for continued use are likely to succeed in BBVC.*

Table 48: Variables of knowledge retention capacity component

<table>
<tr><td colspan="3">INDEPENDENT VARIABLES</td><td>DEPENDENT VARIABLES</td></tr>
<tr><td>Component Level</td><td colspan="2">The knowledge retention capacity</td><td rowspan="4">BIM Business Value Creation (BBVC)</td></tr>
<tr><td rowspan="3">Indicators Level</td><td>1</td><td>Internal transformative capacity</td></tr>
<tr><td>2</td><td>Connective capacity (alliance) with external partners</td></tr>
<tr><td>3</td><td>Connective capacity (alliance) with URIs</td></tr>
</table>

4.6.2.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the knowledge retention capacity has a significant correlation with BBVC. This involved analysing the effect of three knowledge retention capacity indicators in predicting BBVC. The preliminary analysis shows that all assumptions are valid and the potential indicator variables are accepted to carry out the multiple regression analysis.

Table 49: Model summary for the knowledge retention capacity component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.674a	.454	.447	1.05907

a. Predictors: (Constant), Internal transformative capacity, Connective capacity (alliance) with external partners, Connective capacity (alliance) with URIs

Table 49 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.447 with the $R^2 = 0.454$, which means that the linear regression explains 45.4% of the variance in the data.

Table 50: Anova test for the knowledge retention capacity component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	209.019	3	69.673	62.118	.000b
	Residual	251.244	224	1.122		
	Total	460.263	227			

a. Dependent Variable: BIM adoption Level

b. Predictors: (Constant), Internal transformative capacity, Connective capacity (alliance) with external partners, Connective capacity (alliance) with URIs

Table 50 shows the linear regression's F-test, which has the null hypothesis, $H12_0$, that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows a highly significant P-value; thus, the study can assume that the null hypothesis $H12_0$ is rejected. Hence, $H12_1$ is accepted, which means there is a significant linear relationship at the components level between the knowledge retention capacity of SME architectural firms and BBVC. However, to determine the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the indicator analysis is presented in Table 51.

Table 51: Coefficient showing the linear regression estimates of all the indicators of knowledge retention capacity components on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.770	.204		3.768	.000
	Internal transformative capacity	.535	.106	.513	5.045	.000
	Connective capacity (alliance) with external partners	.104	.107	.115	.980	.328
	Connective Capacity (Alliance) with URIs	.070	.114	.068	.615	.539

a. Dependent Variable: BBVC

Table 51 shows the linear regression estimates of all the indicators, thus testing the four sub-hypotheses, H12a and H12b, including the intercept and the significance levels, on the effect of each IC indicator on the success of a BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows the firms that have the transformative capacity to internally maintain and reactivate knowledge for continued use are likely to succeed in BBVC. However, the firms' connective capacity through alliance and cooperation with external partners to maintain and reactivate knowledge for continued use, and the firm's connective capacity through alliance and cooperation with URIs to maintain and reactivate knowledge for continued use were not found to have any significant effect on BBVC.

4.6.3 KNOWLEDGE EXPLOITATION CAPACITY

This section presents the analysis of the relationship between knowledge exploitation capacities of SME architectural firms and BBVC. Table 52 lists the variables of knowledge exploitation capacity component.

4.6.3.1 HYPOTHESES

H13$_1$: The knowledge exploitation capacities of SME architectural firms have a significant correlation with BBVC.

H13$_0$: The knowledge exploitation capacities of SME architectural firms have no significant correlation with BBVC.

4.6.3.1.1 Sub-Hypotheses

- *H13a: Firms that have an internal exploitation capacity to transmute new knowledge into value are likely to succeed in BBVC.*
- *H13b: Firms that have an external exploitation capacity to internally identify knowledge value and transfer to external partners are likely to succeed in BBVC*

Table 52: Variables of knowledge exploitation capacity component

INDEPENDENT VARIABLES			DEPENDENT VARIABLES
Component Level	The knowledge exploitation capacity		BIM Business Value Creation (BBVC)
Indicators Level	1	Internal exploitation capacity	
	2	External exploitation capacity	

4.6.3.2 THE REGRESSION ANALYSIS

A multiple regression analysis was conducted to investigate whether the knowledge exploitation capacity has a significant correlation with BBVC. This involved analysing the effect of the two knowledge exploitation capacity indicators in predicting the BBVC. The preliminary analysis shows that all assumptions are valid and the potential indicator variables are accepted to carry out the multiple regression analysis.

Table 53: Model summary for knowledge exploitation capacity component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.711[a]	.506	.501	1.00546

. Predictors: (Constant), External exploitation capacity, Internal exploitation capacity

Table 53 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.501 with the $R^2 = 0.506$, which means that the linear regression explains 50.6% of the variance in the data.

Table 54: Anova test for the knowledge exploitation capacity component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	232.800	2	116.400	115.140	.000b
	Residual	227.463	225	1.011		
	Total	460.263	227			

a. Dependent Variable: BBVC.

b. Predictors: (Constant), External exploitation capacity, Internal exploitation capacity

Table 54 shows the linear regression's F-test, which has the null hypothesis, $H13_0$, that there is no linear relationship between the dependent variable and independent variable at the component level (in other words $R^2=0$). The F-test shows F value of 115.14 with a highly significant P-value; thus, the study can assume that the null hypothesis, $H13_0$, is rejected. Hence, $H13_1$ is accepted, which means that, at the components level, there is a significant linear relationship between the knowledge exploitation capacity of SME architectural firms and BBVC. However, to determine the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the indicator analysis is presented in Table 55.

Table 55: Coefficient showing the linear regression estimates of all the indicators of the knowledge exploitation capacity components on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.865	.168		5.158	.000
	Internal exploitation capacity	.592	.063	.583	9.423	.000
	External exploitation capacity	.164	.058	.177	2.853	.005

a. Dependent Variable: BBVC

Table 55 shows the multiple linear regression estimates of all the indicators, thus testing the two sub-hypotheses, H13a and H13b, including the intercept and the significance levels on the effect of each IC indicator on the success of a BIM adoption. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that firms that have internal exploitation capacity to transmute new knowledge into value and the external exploitation capacity to internally identify knowledge value and transfer to external partners are likely to succeed in BBVC.

4.6.4 CONCLUSION ON THE OF THE ANALYSIS OF THE KNOWLEDGE CAPITAL COMPONENTS

The objective of this section was to analyse the influence of KC on BBVC in SME architectural firms. A multiple regression analysis was conducted between the independent variables, consisting of various indicators under the three KC components, and the dependent variable of BBVC. The analysis is a test of the hypotheses, one of which was validated by the results in this section.

The result indicated that all the three components of the KC that were identified in the literature review have a significant correlation with BBVC. However, some indicators were not found to be useful in predicting BBVC, which include: Internal Inventive capacity and URIs Network absorptive capacity of the Knowledge exploration and also Business network Connective capacity and URIs connective Capacity of the Knowledge Retention. In comparison, all the indictors of the Knowledge Exploitation were found to be useful. Figure 19 shows the result of the analysis of the effect of the different indicators on the BBVC. Indicators in reds are those rejected while those in ash are accepted.

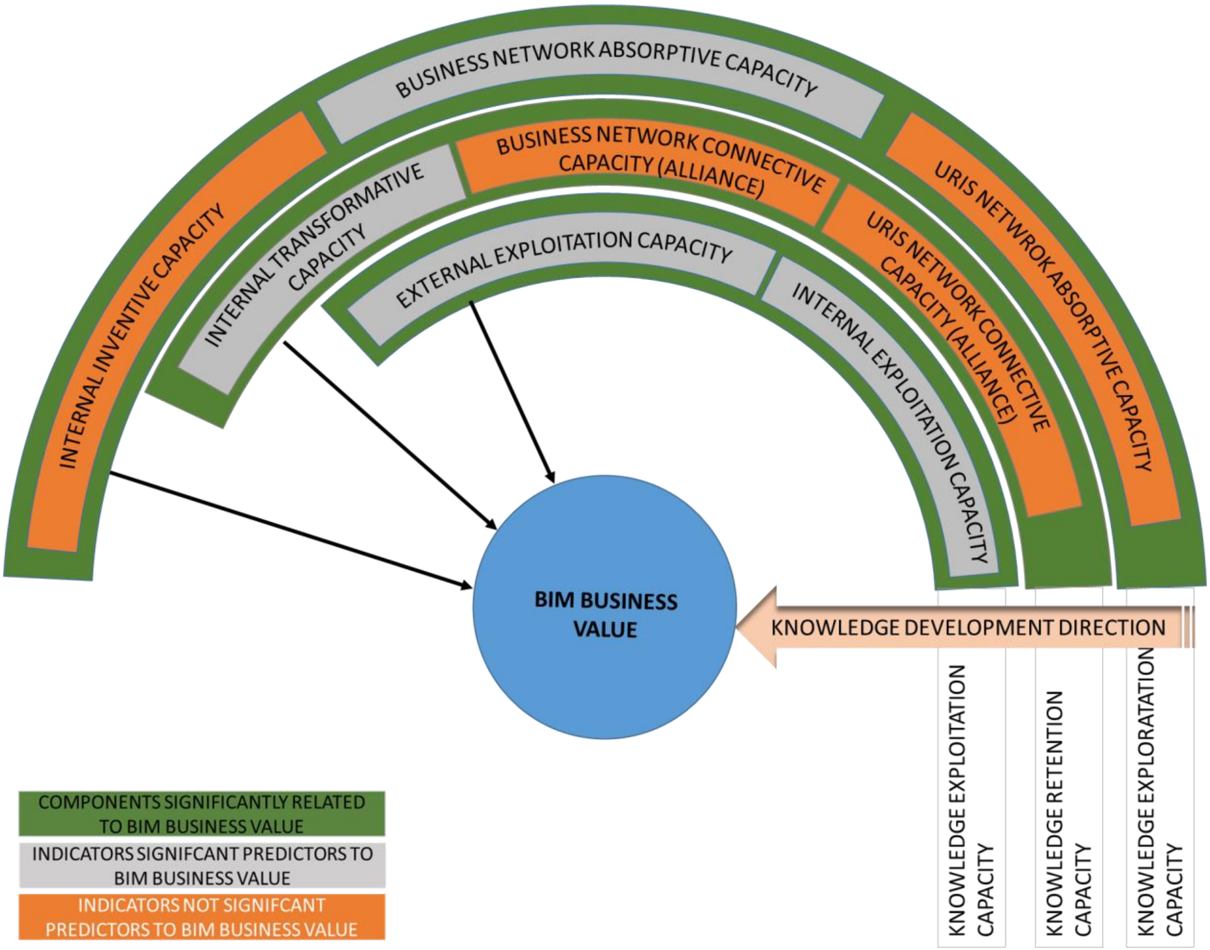


Figure 19: Evaluation for KC, showing the critical components and indicators that predict BBVC

4.7 SUMMARY OF THE FINDINGS

The survey results confirm that the BIM adoption process in SME architectural firms is a knowledge-based innovation, which occurs with the development of the motivation and capability in HC, the motivation and network resource from RC, and the capability and support of SC, through which the resource capacity of KC is formed. For these four capitals to create BBVC, the study identified thirteen crucial components, defined by specific indicators as the critical elements for development.

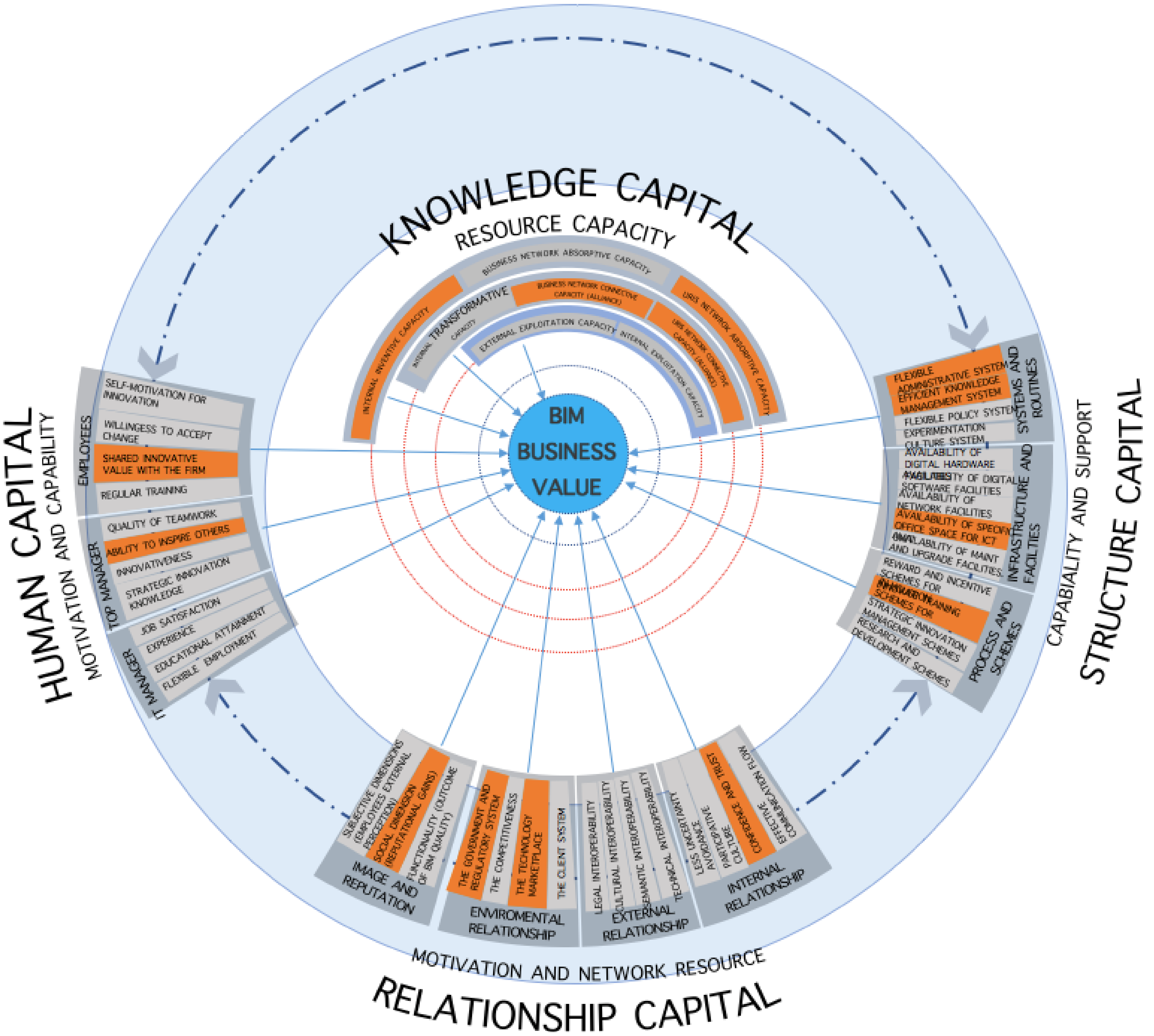


Figure 20: Survey study - the results from the multiple regression analysis

Stratifying the result of the multi-regression analysis, the study deduced the RWV of each of the indicators within a given component, as shown in Table 56 below. The results show the different critical aspects of SME architectural firm's IC development toward achieving the BBVC. The result will later be used for the Strategic Business Model development using the AHP method.

Table 56: Table for the relative weight of the indicators for the IC

Capitals	Components	The variables	The Beta weight
HC	IT manager	Employed on a permanent basis	0.285
		Higher education qualifications	0.425
		Previous IT experience.	0.178
		Higher job satisfaction	0.432
	Top manager	Strategic knowledge of innovation	0.180
		Non-resistance to change	0.219
		The quality of teamwork	0.403
	Employees	Regular training	0.452
		Willingness to accept innovation	0.218
		Self-motivation	0.525
SC	Infrastructure	Availability of digital hardware facilities	0.261
		Availability of digital software facilities	0.236
		Availability of network facilities	0.246
		Availability of maintenance and upgrade facilities for technology.	0.407
	Systems	Flexible policy system for innovation	0.446
		System for experimentation culture	0.279
	Process	Reward and incentive schemes for innovation	0.380
		Strategic innovation management schemes	0.351
		Research and development schemes	0.201
RC	Internal relationship	Internal relationship with efficient	0.235

		communication flow	
		Internal relationship with a participative culture	0.307
		Internal relationship with less uncertainty avoidance	0.196
	External Relationship	Technical interoperability	0.336
		Semantic interoperability	0.236
		Cultural interoperability	0.327
		Legal interoperability	0.439
	Image and Reputation	Functionality (outcome of BIM quality)	0.464
		Subjective dimensions (employees' external perception)	0.188
	Environmental Relationship	Client system in the innovative environment	0.602
		Competitiveness in the innovative environment	0.214
KC	Exploration	Business network absorptive capacity	0.533
	Exploitation	Internal exploitation capacity	0.592
		External exploitation capacity	0.164
	Retention	Internal transformative capacity	0.535

The results suggest that; the development of HC to create BBVC occurs through the motivation and capability of the IT manager, top manager and employees. For the IT manager, this includes work flexibility, educational attainment, previous IT experience, and job satisfaction. For the top manager, this includes the strategic knowledge of innovation, non-resistance to change, and the quality of teamwork; while for employees, it includes regular training, a willingness to accept innovation, and self-motivation.

The development of SC to create BBVC occurs through the support and capability of their infrastructural facilities, the system structure of the firm, and the different process and schemes in place for innovation. Indicators of the infrastructure facilities include hardware, software and networks as well as ensuring the continued maintenance and upgrade of all facilities. The system structure includes a flexible policy system to accommodate innovative ideas and a system that allows for the experimentation of ideas. The process and schemes include rewards and incentives schemes, strategic innovation management schemes, and research and development schemes.

The development of RC to create BBVC occurs through the motivation and network resource resulting from the internal relationships, external relationships, environmental relationships, and from image and reputation. The internal relationship includes the efficient communication flow, a participative culture and less uncertainty avoidance within the firm's social unit. The external relationship includes the interoperability of the firm that allows it to operate with its external partners based on technical, semantic, cultural and legal dimensions. Image and reputation includes the outcome of the BIM quality and subjective employee's perceptions. The environmental relationship includes the client system and the competitiveness of the innovation environment.

The development of the knowledge resource to create BBVC occurs through the capacity of the firm to manage their knowledge exploration, knowledge exploitation and knowledge retention capacities. The knowledge exploratory capacity includes the business network's absorptive capacity, whilst the knowledge exploitation capacity includes the internal and external exploitation capacity. Finally, the knowledge retention capacity includes the internal transformative capacity.

5 CHAPTER FIVE: THE CASE STUDY ANALYSIS

5.1 CHAPTER OVERVIEW

This chapter presents the analysis of the case study, which is central to two objectives; the first objective is to identify the different ways in which firms with BIM capabilities develop their IC for BBVC; this uses the analysis of the semi-structured interviews with six Nigerian architectural firms with relative BIM capabilities. The result is compared with the survey results in order to establish data reliability and validity. The second objective is to identify the RWV for the different IC elements and the extent of their contribution to BBVC. This uses a pairwise comparison analysis, carried out with the same firms involved in the interview. The interview is analysed using NVIVO (software for qualitative research analysis), which includes a hierarchy chart presentation, called TreeMap. TreeMap presents all the IC elements used by the firms with BIM capabilities and shows the results in comparison to the survey results. However, the later RWV is achieved through analysing the questionnaire outcome of a pairwise comparison test. The firms interviewed were familiar with the different themes of the interview, which are deliberately based on the thirteen components of the IC. As such, they were asked to compare the different sets of components using the pairwise comparison method. The data was then analysed using the normalised principal Eigenvector method to identify the RWV for the various elements. The outcome of this chapter forms the basis for the synthesis of a strategic business model for BIM-based innovation, which is presented in Chapter Six. Finally, the paired comparison is presented as a matrix table and provides consistency details based on the Eigenvector recommendations.

5.2 VERTICAL ANALYSIS FOR EACH OF THE SIX INTERVIEWS AGAINST THE FOUR CAPITALS

This section discusses the vertical analysis for each of the six sources of the thirteen components. Each firm was critically analysed to identify the different ways they individually consider the development of the four capitals. Since the focus of this chapter is on the consolidated analysis of all the sources, it only presents a brief discussion and the summary of the analysis for each of the six firms. However, a detailed discussion and analysis for each firm, showing the NVIVO-generated hierarchy charts and the pairwise comparison tables can be found in Appendices G1 to G6 each representing details of Firm 1 to Firm 6, respectively.

5.2.1 FIRM 1

FIRM 1 is a registered architectural firm operating in Kaduna, the northern part of Nigeria. The firm, which has ten employees, adopted BIM in their practice three years ago. The firm's purpose in adopting BIM was to simplify its workflow, improve its efficiency, reduce the use of paper in the office, and align itself with recent trends in the industry. The firm's strategic plans for the adoption and implementation of BIM were achieved by: assessing their IT capability, assessing their staff's capacities and capabilities, and assessing the BIM capabilities of their business partners. This meant drafting a new workflow for implementation. The firm uses paper, 2D models, and 3D models to exchange information within and outside the firm. Hence the firm is at BIM Level 2, where their capability is based on Model-Based Collaboration.

5.2.1.1 FIRM 1: ANALYSIS OF THE DEVELOPMENT OF THE FOUR CAPITALS

The analysis (Appendix G1 for detail) shows that FIRM 1 recognises the motivation and capabilities of the IT manager, top manager and employees in the development of their HC when adopting and using BIM technology. They indicate that, for FIRM 1, the ability of the top manager to inspire others, identified earlier within the literature, is an essential part of their motivation to form BBVC; however, this finding contradicts the survey result, which rejected the effect. Nevertheless, all other indicators are accepted by the survey results and referenced by FIRM 1 as essential for their HC motivation. Also, the analysis identifies two indicators that are neither acknowledged by the survey method nor the literature, and these are: effective communication skills required of the top manager to appropriately convey innovation ideas, and the supervisory role of the IT manager in overseeing the management of IT-related activities in the firm. The firm suggests that their success heavily lies on the ability of the top management to clearly demonstrate the importance of BIM technology to all staff and ensure effective implementation.

Furthermore, the RC analysis indicates that FIRM 1 affirms the importance of the motivation and network resources resulting from the firm's internal, external and environmental relationships, and their image and reputation. However, despite the importance of the government and regulatory bodies in driving innovation, as acknowledged within the literature, neither the survey results nor the interview with FIRM 1 confirm its influence on BBVC. The firm argues that this is because the government is yet to push for BIM adoption. Hence, there is currently neither regulation nor coordination from the government. Nevertheless, FIRM 1 reiterates the effect of two indicators as essential to its value creation, and these accord with the literature, despite their rejection within the survey results. These indicators are: BIM technology dynamism from the environment, and the confidence and trust from internal relationships. Furthermore, the analysis indicates a potential new indicator, namely marketability, as a motivation for developing the image and reputation of the firm to create value. Apart from these differences, FIRM 1 mentions all the other RC indicators accepted by the survey results, and confirm their importance for their motivation and network resource.

Moreover, the firm affirms the importance of all three SC components identified. Although most indicators accepted by the survey results are confirmed as essential, the firm does not mention the network facility. Instead, a new indicator, namely a change management system, is identified under the system component. Meanwhile, the firm rejects the same indicators as the survey, which the literature defines as essential for BBVC. These are: a flexible administration system and an effective knowledge management system (under the system component), the office infrastructure (under infrastructure), and the in-house training schemes (under the process component). Finally, in terms of KC, the firm affirms all the indicators identified by the literature. However, the firm also confirms the effect of URIs' network absorptive capacity and the internal inventive capacity as essential to its BBVC; this is in line with the literature, although rejected within the survey results.

5.2.1.2 FIRM 1: PAIRWISE ANALYSIS SHOWING THE PRIORITY OF THE COMPONENTS

This section presents the result of the pairwise comparison analysis of FIRM 1, which is based on their judgement of the priority weight carried by each component within the four capitals. This is followed by the pairwise comparison of the four capitals. The decision matrix and the priority weight tables for each of the four sets are presented with details of the analysis. The result provides with the weight of each component and the four sets of capitals.

The result suggests that, with a percentage of 66%, FIRM 1 considers the motivation and capability of their top manager as more critical to their HC development in BBVC; this is followed by that of employees at 19% and the IT manager at 16% (Appendix G1-). Under the RC, (Appendix G1-), the firm considers the motivation and network resources resulting from image and reputation, and internal relationships as the most critical at 46% and 41% respectively. This is followed by the external relationship at 10% and an insignificant percentage for the environmental relationship. For the SC, (Appendix G1-Table 7.4.2:3), the firm considers the support and capability resulting from their infrastructure significantly relates to the development of their SC in BBVC; thus, there is a significant effect on the components of system structure (at 20%) and process schemes (at 10%). In the case of KC, (Appendix G1-), the firm considers their knowledge exploration capacity in the development of their KC as most critical for BBVC, with the percentage of 64%. This is followed by the knowledge exploitation capacity at 26%, and knowledge retention capacity, at 11%. However, the analysis (including the firm's pairwise comparison) indicates that, based on the relative importance of the four capitals (Appendix G1), SC is more critical, with a 56% relative importance. This is followed by HC at 29%, whilst RC is at 10%, and KC is at 7%

5.2.2 FIRM 2

FIRM 2 is a registered architectural firm based in Abuja, the capital city of Nigeria. With ten employees, the firm adopted BIM in their practice three years ago due to their service delivery and because of competition and client demand. BIM is not part of their mainstream strategic plan but there is an ad hoc strategy in place when the need for BIM arises. However, when the study assessed the firm, it was found that they use BIM models to interoperate with other stakeholders, as they employ BIM experts to do the work when needed. Hence the firm is at BIM Level 2 where its capability is based on Model-Based Collaboration.

5.2.2.1 FIRM 2: ANALYSIS OF THE DEVELOPMENT OF THE FOUR CAPITALS.

The analysis (Appendix G2 for detail) indicates that FIRM 2 does not recognise the motivation and capability of their ordinary employees in BBVC, except for that of the IT manager who is employed on a temporary basis (Appendix G2). However, the motivation and capability of the IT manager is seen as the most essential to BBVC in the firm. While the IT manager's efficiency and effectiveness in delivering a quality service indicates value, despite high demand for their service, the firm ensures the IT manager has job satisfaction. The firm also mentioned new indicators, specifically the ability to inspire others, and exposure to emerging technology trends as additional essential elements of the IT manager's contribution. Similarly, the firm indicates that the ability to inspire others is a top manager component, and this accords with the literature, although was rejected by the survey results. Apart from these differences, FIRM 2 references all other indicators accepted by the survey results as essential to their motivation and capabilities in developing their HC.

Furthermore, FIRM 2 affirms the importance of the RC motivation and network resource resulting from the firm's internal, external, and environmental relationships and their image and reputation. Although, FIRM 2 affirms all the indicators under the environmental relationship that were also accepted by the survey results, only the participatory culture indicator is referenced under the internal relationships. However, the confidence and trust indicator reference echoes that of the literature, despite its rejection within the survey results. Paradoxically, under the image and reputation components, all the indicators accepted within the survey results are referenced; however, social reputation, which is mentioned within the literature, is also confirmed along with a new indicator, called marketability.

Moreover, the firm affirms the importance of all three SC components. The analysis shows that a flexible policy system (under the system structure component), rewards and incentives (under process and software), and hardware and maintenance (under the infrastructural facilities component) are the only indicators accepted by the survey results and referenced by FIRM 2. Nevertheless, the administrative system component, which was rejected within the survey results, is confirmed as an essential indicator of the system's structure.

Finally, in terms of KC, the firm only affirms the internal transformative capacity indicator (under the knowledge retention capacity) as a resource for KC; this is reflective of the survey results. Similarly, under the exploration capacity, the business network absorptive capacity indicator is mentioned, which is in line with the survey results; however, the firm also reiterates the significance of URIs, which is in line with the literature. Meanwhile, in the case of knowledge exploitation, the external exploitation capacity is the only indicator mentioned.

5.2.2.2 FIRM 2: PAIRWISE ANALYSIS SHOWING THE PRIORITY OF THE COMPONENTS

This section presents the results of the pairwise comparison analysis of FIRM 2 on their judgement of the priority weighting of each component within the four capitals. This is followed by a pairwise comparison of the four capitals themselves. The decision matrix and priority weight tables for each of the four sets are presented with details of the analysis. The results provide the weight of each component and each of the four capitals. The results indicate that, with a percentage of 74%, FIRM 2 considers the motivation and capability of their IT manager as relatively more critical in their HC development for BBVC. The top manager follows this, at 21%, and then employees, at 5.8% (Appendix G2).

Under the RC, (Appendix G2), the firm considers the motivation and network resources resulting from external relationships as the most critical, at 62%. This is followed by internal relationships at 20%, and image and reputation at 13%, whilst a small percentage is attributed to environmental relationships, at 5%.

Furthermore, at 78% (Appendix G2), the results suggest that the firm considers the support and capability resulting from their infrastructure most significantly relates to the development of their SC in BBVC. They also indicate a significant effect on the system structure, and process schemes components, at 11% each. Moreover, at 63% (Appendix G2), the firm considers their knowledge exploitation capacity in the development of their KC as more critical in BBVC. This is followed by their knowledge exploration capacity, at 30%, and their knowledge retention capacity, at 6%. However, in summary, and based on the relative importance of the four capitals (Appendix G2), the pairwise comparison of the firm indicates that the Human, Relationship and Structural Capitals have an equal relative importance at 31% each, while Knowledge Capital has only 6%.

5.2.3 FIRM 3

FIRM 3 is a registered architectural firm operating in Abuja, the capital city of Nigeria. The firm adopted BIM in practice just a year ago, and has 13 employees although about eight are involved in BIM processes. The firm adopted BIM in order to align itself with international best practice and improve the efficiency and production in its service delivery. Part of its strategic plans for the adoption and implementation of BIM mean developing the motivation and capability of their HC, and making their innovation process open to their partners. This strategy also helps some of their partners develop an interest in using BIM technology. The assessment of the firm by the study reveals that it uses both an adequate BIM model and digital models to share information with their stakeholders within and outside the firm. Hence the firm is at BIM Level 2 where its capability is based on Model-Based Collaboration.

5.2.3.1 FIRM 3: ANALYSIS OF THE DEVELOPMENT OF THE FOUR CAPITALS.

The analysis (Appendix G3 for detail) shows that FIRM 3 recognises the motivations and capabilities of the IT manager, top manager and employees in the development of their HC in BBVC. It indicates that the ability of the top manager to inspire others, as identified in the literature, is an essential part of their motivation to form BBVC, despite its rejection within the survey results. However, the firm also mentions all other top manager components that were accepted by the survey results. Nevertheless, the firm also mentions a new indicator of communications skills. In addition, the firm indicates the importance of employees' shared innovative values, suggesting that this is an essential part of their motivation, and that the best and integral resources enable a BIM process (Appendix G3). Aside from these differences, all other indicators mentioned by the firm are also accepted by the survey results.

Furthermore, within its RC, FIRM 3 affirms the importance of the motivation and network resources resulting from its internal, external, and environmental relationships and from its image and reputation. Similar to FIRM 2, the participatory culture relationship (under internal relationships) is the only indicator accepted by the survey and mentioned by the firm. Meanwhile, the firm mentions confidence and trust, which is identified in the literature, but rejected within the survey results. Paradoxically, the social reputation indicator is mentioned, which accords with the literature, whilst a new indicator of marketability (under the image and reputation components) is mentioned; however, those accepted by the survey results are not mentioned. Nevertheless, under the environmental relationship, a new indicator of training institutions is identified in driving motivation and network resources. In addition, the technology dynamism indicator is mentioned and this is in line with the literature, but rejected within the survey results. Nevertheless, all other indicators mentioned by FIRM 3 are also accepted within the survey results.

In terms of SC, the firm affirms the importance of the infrastructure components, mentioning almost all the indicators identified by the survey result and the literature; indeed, only the network facilities are not mentioned. However, in the case of the system structure, only the flexible policy system is in line with the survey results; meanwhile, the flexible administrative system is in line with the literature. Additionally, a new indicator of a change management system is identified as an essential indicator. Under the process schemes, the rewards and incentives indicator is identified, which accords with the survey results, but the strategic innovation management schemes, and the research and development are not mentioned. However, the firm mentioned in-house training as essential to their support and capability, which is reflected in the literature although rejected within the survey result.

Finally, in terms of KC, the firm affirms that only the internal transformative capacity indicator (under the knowledge retention capacity) is a resource for KC; this echoes the survey results. Similarly, under the exploration capacity, the business network absorptive capacity indicator is mentioned, which also reflects the survey result; however, the internal inventive capacity echoes the literature findings. Meanwhile, in the case of knowledge exploitation, the internal exploitation capacity is the only indicator mentioned.

5.2.3.2 FIRM 3: PAIRWISE ANALYSIS SHOWING THE PRIORITY OF THE COMPONENTS

This section presents the results of the pairwise comparison analysis of FIRM 3 concerning their judgement of the priority weight carried by each component within the four capitals. These will be followed by the pairwise comparison of the four capitals. The decision matrix and the priority weight tables for each of the four sets are presented with further detail of the analysis. The result provides the weight of each component and the four capitals.

The HC result indicates that, with a percentage of 46%, FIRM 3 considers the motivation and capability of their employees as most critical to their HC development in BBVC. Their IT manager follows this, at 32%, and their top manager, at 22% (Appendix G3)

Under their RC, (Appendix G3), the firm considers the motivation and network resource resulting from internal relationships as most critical, at 51%. This is followed by their external relationships, and their image and reputation, at 27% and 18% respectively. At 4%, only a small percentage weighting is attributed to their environmental relationships. Moreover, at 73.5% (Appendix G3), the result suggests that the firm considers the support and capability resulting from their infrastructure significantly relates to the development of their SC in BBVC. In addition, a significant effect relates to their system structure components (at 21%) and their process schemes (at 6%). In terms of the impact of KC on BBVC (Appendix G3), the firm considers their knowledge exploitation capacity as most critical (at 58%), which is followed by their knowledge exploration capacity (28%) and then their knowledge retention capacity (at 14%). Thus, based on the relative importance of the four Capitals (Appendix G3), the pairwise comparison result indicates that the HC aspect is most critical with a 64% relative importance. This is followed by the SC, with 21%, and the RC, with 10%; the least significant is KC with 5%.

5.2.4 FIRM 4

FIRM 4 is a registered architectural firm based in Zaria, Kaduna State. The firm adopted BIM in practice three years ago, and has eleven employees almost all of whom are involved in BIM processes. The firm uses various software to deliver their BIM services, and their goal in adopting BIM technology is to achieve a level in which all designs would be BIM compliant, from the initial sketch through to the implementation of the maintenance or post occupancy service. However, that is a vision yet to be achieved, according to the assessment by the study. The firm explained they are currently in a transition phase, moving from the hybrid design process of combining traditional methods to the 100% digitised method of practice (where all design documentation is in a single BIM file). The assessment of the firm by the study reveals that the emphasis in this firm is more in visualisation than information sharing. However, the firm uses digital models to share information with their various stakeholders, both within and outside the firm. Hence the firm is at BIM Level 2 where its capability is based on Model-Based Collaboration.

5.2.4.1 FIRM 4: ANALYSIS OF THE DEVELOPMENT OF THE FOUR CAPITALS.

The analysis (Appendix G4 for detail) shows that FIRM 4 recognises the motivation and capabilities of the IT manager, top manager and its employees in the development of their HC and the adoption and use of BIM technology. Although the job satisfaction indicator is not referenced under the components of IT manager, the analysis references instead the exploration of a new indicator featuring the IT manager's exposure to emerging technology trends in the industry. However, in addition to the experience and nature of employment, which is identified in the survey results, the firm indicates that some knowledge particular to the architectural profession is also essential for the IT manager. As for the top manager, the firm describes their qualities as being innovative as well as having all the necessary strategic knowledge in innovation management, coupled with the quality of teamwork. This brings it in line with the survey results. FIRM 4 identifies all the indicators under the employees' components, which echoes the survey result; they also mention the shared innovative value indicator, which accords with the literature.

In line with the survey results, the analysis indicates that FIRM 4 recognises all the RC components. Under the internal relationship components, the firm recognises all the indicators provided by the survey result and includes the exploration of a new internal relationship indicator of team-working. However, it shows a slightly different result regarding image and reputation, where only the output quality indicator is in line with the survey result; however, the social reputation indicator is only recognised within the literature. Furthermore, only the client system is recognised in the environmental relationships, which just accords with the survey results. However, under the external relationship components, most indicators are accepted, excepting the legal interoperability. This might be because the firm mentions contractual issues under the environmental relationship, which indicates the effect of the regulatory system and echoes the literature results.

In terms of SC, the firm recognises all the facilities acknowledged by the survey result under the infrastructure components; these are the software, hardware, networks, and upgrade and maintenance. However, under the process and schemes components, only research and development is recognised, and this echoes the survey result. This suggests the firm does not formalise the strategic innovation management features of the top management, nor employ the incentives schemes indicated by the survey results. Similarly, under the system structure components, the firm only recognises the flexible policy system as a formal system in the firm for supporting BIM innovation.

In terms of KC, the firm does not conform with the survey result at all concerning its exploration capacity; it recognises only an internal inventive capacity as its knowledge exploration resource. This is, however, in line with the literature findings. The same situation is recorded under the knowledge retention capacity, and knowledge exploitation capacity as the firm only recognises their internal transformative capacity and internal exploitation capacity respectively as their way of managing their knowledge resources.

5.2.4.2 FIRM 4: PAIRWISE ANALYSIS SHOWING THE PRIORITY OF THE COMPONENTS

This section presents the results of the pairwise comparison analysis of FIRM 4 on their judgements concerning the priority weight carried by each component within a set of four capitals. This is followed by the pairwise comparison of the four capitals. The decision matrix and the priority weight tables for each of the four sets are presented with details of the analysis. The result provides the weight of each component and the four capitals.

The result suggests that, with a percentage of 66%, FIRM 4 considers the motivation and capability of their IT manager as more critical to their HC development in BBVC. Their employees follow this, at 18.5%, and then their top manager, at 17% (Appendix G4). Under the RC, (Appendix G4), the firms consider the motivation and network resource resulting from their image and reputation and internal relationships as the most critical at 51% and 29% respectively. The external relationship follows this, at 15%, and a small percentage is attributed to environmental relationships, at 5%. Moreover, (Appendix G4), the firm considers the support and capability resulting from their system structure significantly relates to the development of their SC in BBVC. This is followed by the impact of the infrastructure (at 28%) and process scheme (at 14%) components. Finally, the analysis suggests that the firm considers all the three KC components as having equal importance (Appendix G4). In summary, based on the relative importance weighting of the four capitals (Appendix G4), the result from the pairwise comparison of the firm indicates that HC is more critical, at 47%. RC follows this at 28%, and then KC at 15%. The least significant is SC at 10%

5.2.5 FIRM 5

FIRM 5 is a registered architectural firm operating in Lagos, the commercial city of Nigeria. The firm is relatively new, having opened only two years ago and is operated by young employees enthusiastic about IT, who have also received University-based IT training. The firm adopted BIM in the early stage of its operation. Their strategy is based on their loose administrative system and the emphasis on innovation for competitive advantage. The firm is multidisciplinary where most of the stakeholders for a BIM model interoperate smoothly. The firm’s multidisciplinary approach has helped it to overcome most of the cultural problems associated with BIM. The assessment of the firm by the study revealed that the firm uses an adequate BIM model and a shared database to efficiently deliver services using the BIM process.

5.2.5.1 FIRM 5: ANALYSIS OF THE DEVELOPMENT OF THE FOUR CAPITALS.

The analysis (refer to Appendix G5 for detail) shows that FIRM 5 recognises all the HC components provided within the survey results. However, it does not accord with some of the indicators selected within the survey results. For example, under the component of IT manager, job satisfaction is not recognised; however, a new indicator of self-motivation is critical for the IT manager. Similarly, in the case of employees, while the analysis suggests self-motivation and regular training as critical, which reflects the survey result, the firm does not recognise employees' willingness for innovation. Nevertheless, the analysis suggests a shared innovative value, which is rejected by the survey but echoes the literature findings. Whilst the firm acknowledges all the indicators regarding the top manager, which is reflected by the survey results, it adds a new indicator, namely communication skills.

In terms of RC, FIRM 5 recognises the motivation and network resources from their internal and external relationships, and their image and reputation; this reflects most of the indicators provided by the literature with the exception of legal interoperability (under the external relationships). However, under the environmental relationship, only the competitive environment indicator was recognised, thus disregarding the effects of clients’ systems, which is selected by the survey result.

Furthermore, the firm recognises all the facilities provided by the survey result under the infrastructure components; these are the software, hardware, network, and upgrade and maintenance and are critical to their SC development. However, under the process and schemes components, the research and development, and strategic innovation management schemes are recognised, echoing the survey result; both the survey and firm disregard rewards and incentives schemes. Similarly, under the system structure components, the firm only recognises the flexible policy system as a formal system supporting BIM innovation in the firm, but acknowledges the flexible admin system indicator indicated by the literature findings.

In terms of KC, the analysis shows that FIRM 5 recognises all the knowledge exploitation and retention capacity indicators, representing the internal and external capacities as well as the inventive transformative capacity; this echoes the survey results. However, the analysis shows the firm's results do not conform with the survey results regarding exploration capacity; instead, the firm recognises the internal inventive and URIs network absorptive capacity, which reflects only the literature findings. In addition, the analysis explored a new indicator recognised by the firm in the form of an internet exploration capacity.

5.2.5.2 FIRM 5: PAIRWISE ANALYSIS SHOWING THE PRIORITY OF THE COMPONENTS

This section presents the results of the pairwise comparison analysis for FIRM 5 on the priority weight judgement for each component within the four capitals. These will be followed by the pairwise comparison of the four capitals. The decision matrix and the priority weight tables for each of the four sets are presented with details of the analysis, and the results provide the weight of each component and the four capitals. With 43% each, the result suggests that FIRM 5 considers the motivation and capability of their IT Manager and employees as more critical to their HC development in term of BBVC, This is followed by the top manager with 14% (Appendix G5)

Under the RC, (Appendix G5), the firms consider the motivation and network resource resulting from internal relationships as the most critical, with 60%. This is followed by the external relationships at 21%, while the environmental relationships and image and reputation have 12% and 7% respectively. Moreover, for the development of their SC in BBVC (Appendix G5), the result suggests that the firm considers that the support and capability resulting from their infrastructure and system structure are most relevant, with a significant effect of 43% each. Meanwhile, the process scheme is at 14%. Furthermore, with a percentage of 58% (Appendix G5), the analysis suggests that the firm considers their knowledge retention capacity in the development of their KC as more critical in BBVC. This is followed by their knowledge exploration capacity at 28% and their knowledge exploitation capacity at 14%. Based on the relative importance of the four Capitals (Appendix G5), the result from the pairwise comparison of the firm indicates that the HC aspect is more critical with a 55% relative importance; the PC follows this with 27%, whilst the SC aspect has 13%, and the KC, 4%.

5.2.6 FIRM 6

FIRM 6 is a registered architectural firm operating in Lagos, the commercial city of Nigeria. The firm adopted BIM in their practice one year ago as part of their business re-engineering process; they did this to improve efficiency and align themselves with international best practice, whilst their goal was to ensure the firm's survival in the increasingly competitive market of Lagos. The first BIM projects by the firm were based on demand from a major client. The client set all the policies and invited the participating firms, including FIRM 6, to contribute. Hence, this client provided the firm’s policies, processes, and their BIM execution plan. An assessment of the research reveals that FIRM 6 operates a well-advanced BIM process where all participants share data through a shared database. An advanced BIM management system is employed for projects, which FIRM 6 tends to operate effectively.

5.2.6.1 FIRM 6: ANALYSIS OF THE DEVELOPMENT OF THE FOUR CAPITALS.

In terms of HC, the analysis (Appendix G6 for detail) shows that FIRM 6 recognises all the same components as indicated in the survey result. Furthermore, the analysis indicates that almost all the indicators of the survey result were essential to FIRM 6, except for the nature of employment under the IT manager component and employees’ willingness for innovative technology. However, the study explores two new indicators that are recognised by FIRM 6 as essential for their BBVC, which are the communications skills of the top manager and the teamwork capabilities of employees.

In terms of RC, the analysis indicates that the firm recognises the motivation and network resources from their internal, external, and environmental relationships and their image and reputation. These accord with most of the indicators provided by the literature, excepting cultural interoperability (under the external relationship), less uncertainty avoidance (under the internal relationship) and the client system (under the environmental relationship). However, the study explored four new indicators that are recognised by FIRM 6 as essential to their BBVC. These are the communication flow through their external relationships, the extent of team working through their internal relationships, the effect of training institutions, under the environmental relationship, and the marketability of their image and reputation.

Additionally, the analysis shows that the firm recognises the capability and support of all three components of SC, also acknowledged within the survey result, as essential to their BBVC. Although, under the systems structure components, the analysis suggests that the firm only recognises the flexible policy system, also acknowledged within the survey result; however, the analysis also explores two new indicators essential for the firm, which are an effective remuneration system and a marketing strategy. These are in addition to the effective knowledge management system, which accords with only the literature findings. On the other hand, the analysis suggests that the firm recognises most of the process and scheme, infrastructure, and upgrade and maintenance indicators, with the exception of the strategic innovation management scheme. However, under the infrastructure facilities components, the office infrastructure analysis only accorded with the literature findings.

Furthermore, the analysis shows that the FIRM 6 recognises the effect of all three KC components provided by the survey. The firm thereby recognises most of the indicators of the survey result, except the external exploitation capacity. However, the analysis explores new indicators under the exploration capacity that are essential to the FIRM 6, which are the software vendors (technology marketplace) and the internet exploration capacity. These are in addition to URIs' network absorptive capacity, which is only acknowledged within the literature findings.

5.2.6.2 FIRM 6: PAIRWISE ANALYSIS SHOWING THE PRIORITY OF THE COMPONENTS

This section presents the result of the pairwise comparison analysis of FIRM 6 on their priority weight judgement for each component within the four capitals. These will be followed by the pairwise comparison of the four capitals. The decision matrix and the priority weight tables for each of the four sets are presented with details of the analysis. The result provides the weight of each component and the four capitals. The result suggests that FIRM 6 considers the motivation and capability of their top manager as more critical to their HC development in BBVC, with a percentage of 71%. The employees and IT manager follow this with 14.3% each (Appendix G6). Under the RC (Appendix G6), the firms

consider the motivation and network resource resulting from internal relationships as most critical with 48%. This is followed by external relationships, with 28%, while image and reputation, and the environmental relationship have the least with 16% and 9% respectively.
With 66%, the firm considers the support and capability resulting from their infrastructure significantly relates to the development of their SC in BBVC (Appendix G6). While the system structure, with 15% and the process schemes with 19% are considered less significant. In the case of KC (Appendix G6), the analysis suggests that the firm considers their knowledge exploration capacity, with a percentage of 73%, is more critical in their BBVC. This is followed by the knowledge exploitation capacity with 19% and the knowledge retention capacity with 8%. However, in terms of the relative importance of the four capitals (Appendix G6), the result from the pairwise comparison of the firm indicates that HC is more critical with a 57% relative importance. RC follows this with 12%, and SC with 12%, whilst the least important is KC with 7%.

5.3 CONSOLIDATED ANALYSIS FOR EACH OF THE FOUR CAPITALS AGAINST THE SIX INTERVIEWS FOR THE CASE STUDY

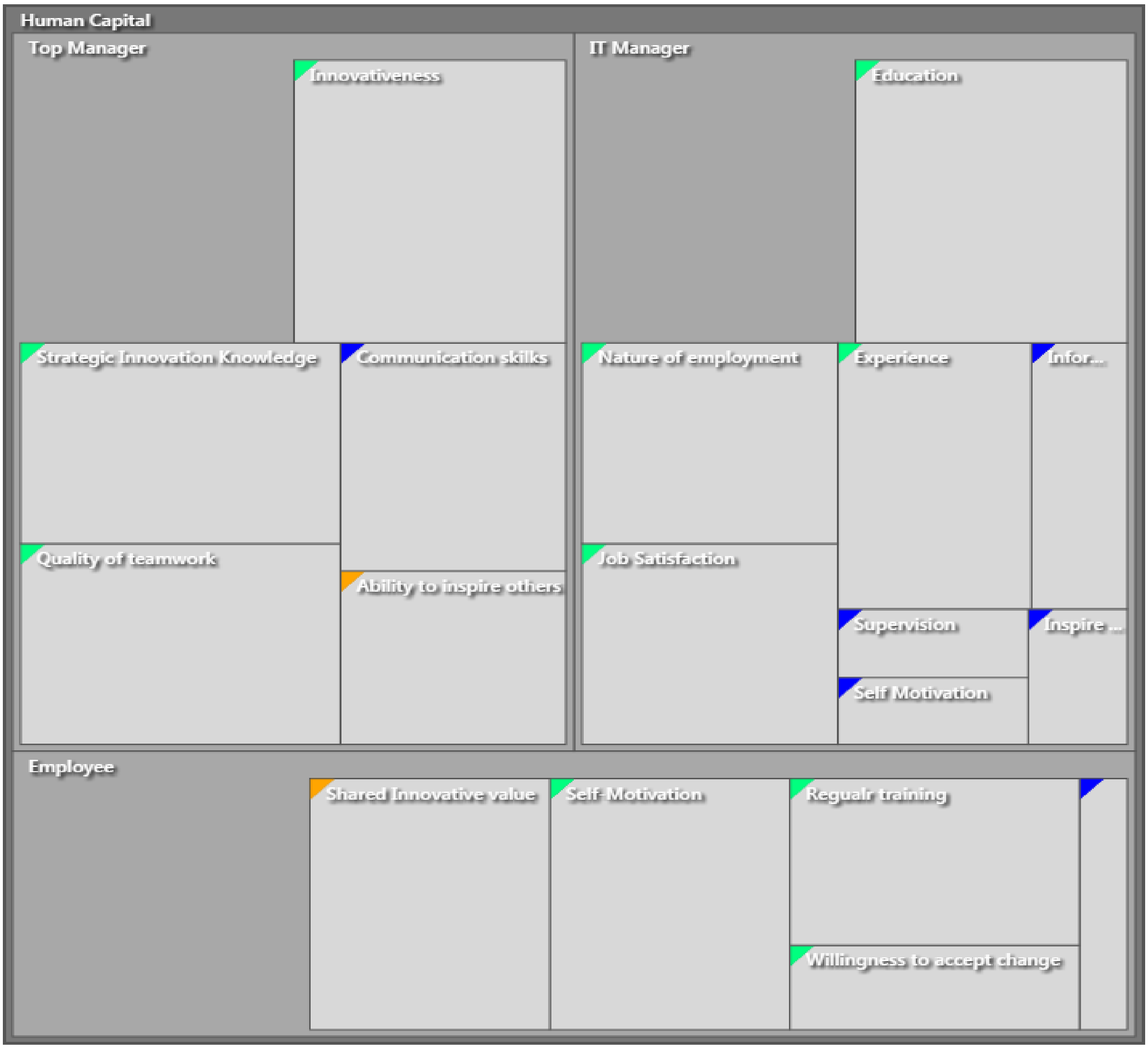
This section discusses the consolidated analysis of the six case studies and, similar to the vertical analysis above, the discussion is based on two foci, which are; firstly, to identify the different indicators that are referenced across all the six case studies and compare them with the survey results; this will ensure the results are triangulated. The presentation approach is similar to that of the vertical analysis where colour coding is used to represent the status of each indicator in the hierarchy chart. Secondly, the RWV is determined for each of the IC elements based on the consolidated pairwise comparison across all six case studies. This is based on the normalised principal Eigenvector, which identifies the consolidated agreement of several pairwise comparison sources. The analysis is organised into four categories where each represents one of the four capital aspects.

5.3.1 ANALYSIS OF THE HC ELEMENTS

This section addresses the consolidated analysis of the HC elements of the case study. It involves two stages, which are the consolidated interview analysis using NVIVO software, and the consolidated interview analysis using the pairwise comparison, and the normalised principal Eigenvector.

5.3.1.1 CONSOLIDATED INTERVIEW ANALYSIS USING NVIVO SOFTWARE

This section presents the results of the consolidated HC analysis and involves the consolidation of the interview analysis with firms comprising the case study. The results are presented using the hierarchy chart, TreeMap, showing the number of references, coded per indicator, within a set for each component. The results presented using TreeMap show the size, and thus significance, of an entity by the number of references. The status of each referenced indicator in the triangulation is coded using different colours. The colours in green are the indicators, which are identified in the literature as well as in the survey results. The colours in orange are those identified in the literature but not accepted by the survey result. The colours in blue are those indicators identified only in the case study analysis. The four segments in the chart show the analysis of each set of components in HC, RC, SC and KC



Generated by NVIVO 11 Software

Key:

Green: Indicators accepted by survey and confirmed by the case study analysis	**Orange:** Indicators identified by literature but only confirmed by Case study analysis	**Blue:** New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 21: Hierarchy chart, TreeMap, showing the analysis of data triangulation based on the HC for all sources

Figure 21 shows the Hierarchy chart for the consolidated interview. The TreeMap shows the size of significance, of an entity by the number of references provided from the six sources. The results suggest that each of the indicators provided by the survey result has a significant amount of references from the case study analysis of the six companies. The result suggests that, under the motivation and capability components of the IT manager, the firms identify the importance of all the same indicators as the survey result, but also note four new indicators, which are neither identified through the literature nor the survey results. These include the following IT manager characteristics: being informed on emerging technology trends, supervisory qualities, self-motivation, and the ability to inspire others. Similarly, under the motivation and capability components of the top manager, the firms identify the same indicators as the survey result. However, they also note one new indicator for the top manager, namely communication skills and this has significant reference amongst the firms. In addition, the top manager's quality of inspiring others is identified in the case study analysis, but is only noted within the literature and not for the survey study.

Furthermore, for the motivation and capability component of employees, the firms identify all the indicators noted by the survey result. However, they also identify one new indicator, which is the teamwork capabilities of employees, and this has a significant number of references. In addition, employees' quality of sharing innovative value with a firm is identified by the case study analysis, which is noted within the literature but not accepted within the survey study. Thus, the findings from the survey regarding the HC aspect are established as reliable and valid for synthesis in the business model for BBVC.

5.3.1.2 CONSOLIDATED PAIRWISE COMPARISON ANALYSIS OF THE HC

This section presents the result of the consolidated analysis of the pairwise comparison using the normalised principal Eigenvector. The principle is based on the premise that the separate judgements of all six firms converge toward a common outcome through a certain level of consensus. Hence, the result presented here includes all the details regarding the level of the consensus and the outcome of the HC data. This section presents the analysis of the consolidated RWV for the HC components, namely the IT manager, top manager and employees.

Table 57: Matrix table for the normalised principal Eigenvector showing the consolidated RWV for the HC components

Matrix	**IT manager**	**Top manager**	**Employees**	**Normalised principal Eigenvector**
IT manager	1.00	1.20	1.73	42%
Top manager	0.83	1.00	1.42	34%
Employees	0.58	0.70	1.00	24%
Number of comparisons	3			
Number of participants	6			
Consensus	66%			
Consistency Ratio CR	0.37			
GCI	0.00			
Consistency Ratio CR	0.0%			
Principal Eigen value	3.000			
Eigenvector solution: 8 iterations, Thresh = 1E-070 , EVM check:= 2.5E-08				

Eigenvalue					lambda:	**3.000**
Consistency Ratio	0.37	GCI:	0.00		CR:	0.0%

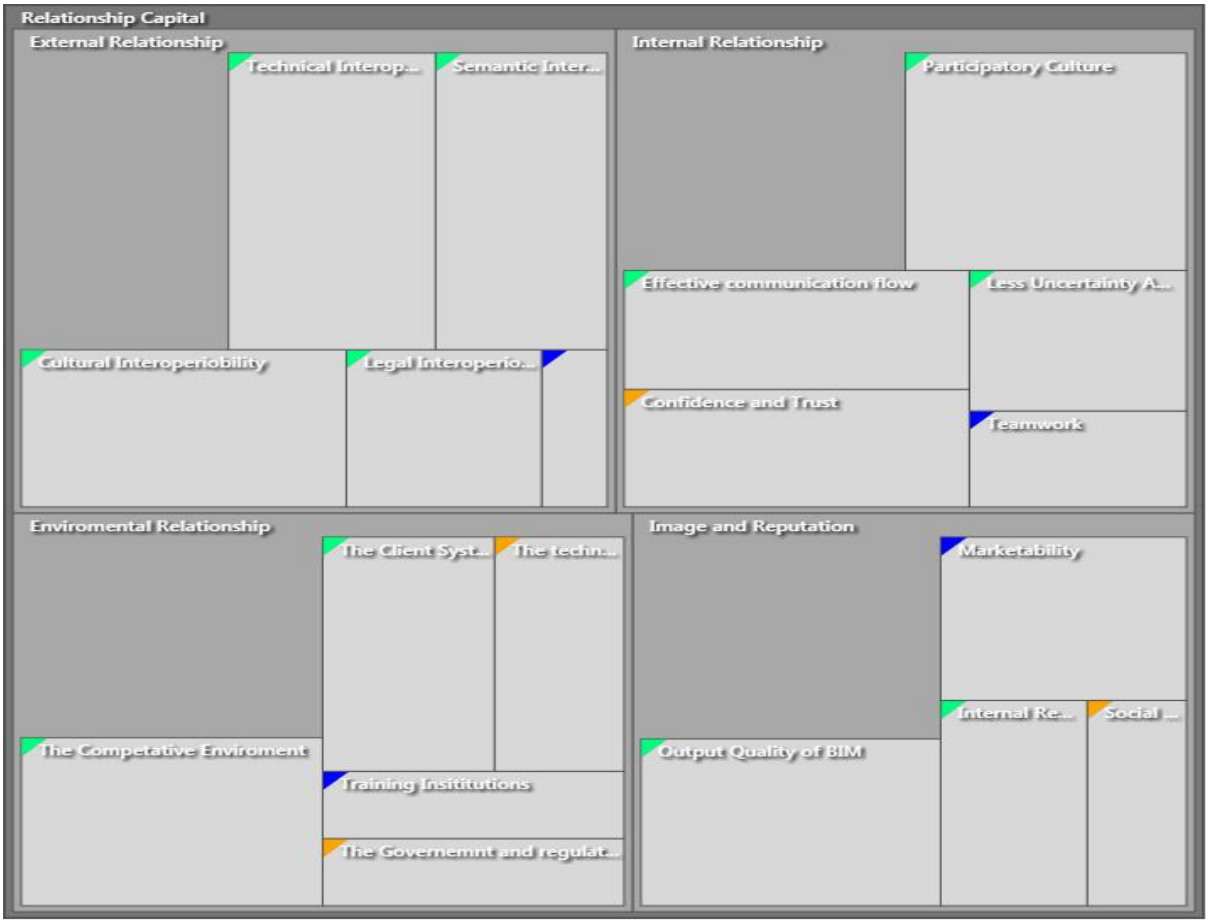
Table 57 shows the matrix table for the normalised principal eigenvector analysis of the consolidated RWV for HC components. The analysis comprising the six case study participants yield a 66% consensus result, with a consistency ratio of 0.37. The result indicates that the IT manager is the first in priority regarding the HC components, with a weight of 42%, the top manager components are rated second, with 34% and then the employee components with 24%.

5.3.2 ANALYSIS OF THE RC ELEMENTS

This section presents the consolidated analysis of the RC elements of the case study. It involves two stages, which are the consolidated interview analysis using NVIVO software and the consolidated interview analysis of the pairwise comparison using the normalised principal Eigenvector.

5.3.2.1 CONSOLIDATED INTERVIEW ANALYSIS USING NVIVO SOFTWARE

This section presents the RC consolidation from the interview analysis and is presented using TreeMap, showing the amount of references coded per indicator within each component set.



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Key:

Green: Indicators accepted by survey and confirmed by the case study analysis	**Orange:** Indicators identified by literature but only confirmed by Case study analysis	**Blue:** New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 22: Hierarchy chart, TreeMap, showing the analysis of the data triangulation based on the RC elements

The result suggests that each indicator identified by the survey result has a significant number of references through the case study analysis of the six firms. This suggests that, under the motivation and network resource components within the internal relationships driving BBVC, the firms identify the importance of all indicators acknowledged by the survey. In addition, the case study also identifies the confidence and trust indicator for internal relationships, which is identified by the literature but not accepted within the survey data. The study also identifies a new indicator, namely team working, which is neither identified within the literature nor the survey results.

Moreover, for the motivation and network resource components resulting from the external relationships, the firms similarly identify all the indicators provided by the survey results. However, there is one new indicator noted as a critical to BBVC, which is the extent of the communication flow amongst external relationships, and this has a significant number of references, as shown in Table 58. Nevertheless, for the motivation and network resource component resulting from environmental relationships, the firms identify the same indicators as the survey result. However, there they also note a new indicator that has a significant amount of references, namely training institutions. Nevertheless, even although the government and regulatory body, and technology dynamism indicators are identified in the literature but not accepted by the survey result, the case study analysis identifies them as significant, as shown in Figure 22 .

Regarding the motivation and network resource component concerning image and reputation, the firms identify the same indicators as the survey result. However, identified with a significant amount of references, the firms note a new indicator, which is the extent of marketability derived as a result of image and reputation.   Nevertheless, even although the social reputation indicators are identified in the literature but not accepted by the survey result, the case study analysis acknowledges it as an indicator, with a significant amount of coding. To summarise, the findings from the survey study regarding the RC aspect are established as reliable and valid for synthesis within the business model for BBVC.

5.3.2.2 CONSOLIDATED PAIRWISE COMPARISON ANALYSIS OF THE RC

This section presents the results of the consolidated analysis of the pairwise comparison using the normalised principal Eigenvector. The principle is based on the premise that the judgements of these six firms converge toward a common outcome with an accepted level of consensus. Hence, the result presented here includes all the details regarding the level of the consensus and the outcome of the RC.

Table 58: Matrix table for the normalised principal Eigenvector showing the consolidated RWV for the RC components

Matrix	Internal Relationship	External Relationship	Environmental Relationship	Image and Reputation	**Normalised principal Eigenvector**	
Internal Relationship	1.00	2.26	5.43	1.89	45%	
External Relationship	0.44	1.00	4.65	1.36	26%	
Environmental Relationship	0.18	0.21	1.00	0.27	7%	
Image and Reputation	0.53	0.73	3.76	1.00	22%	

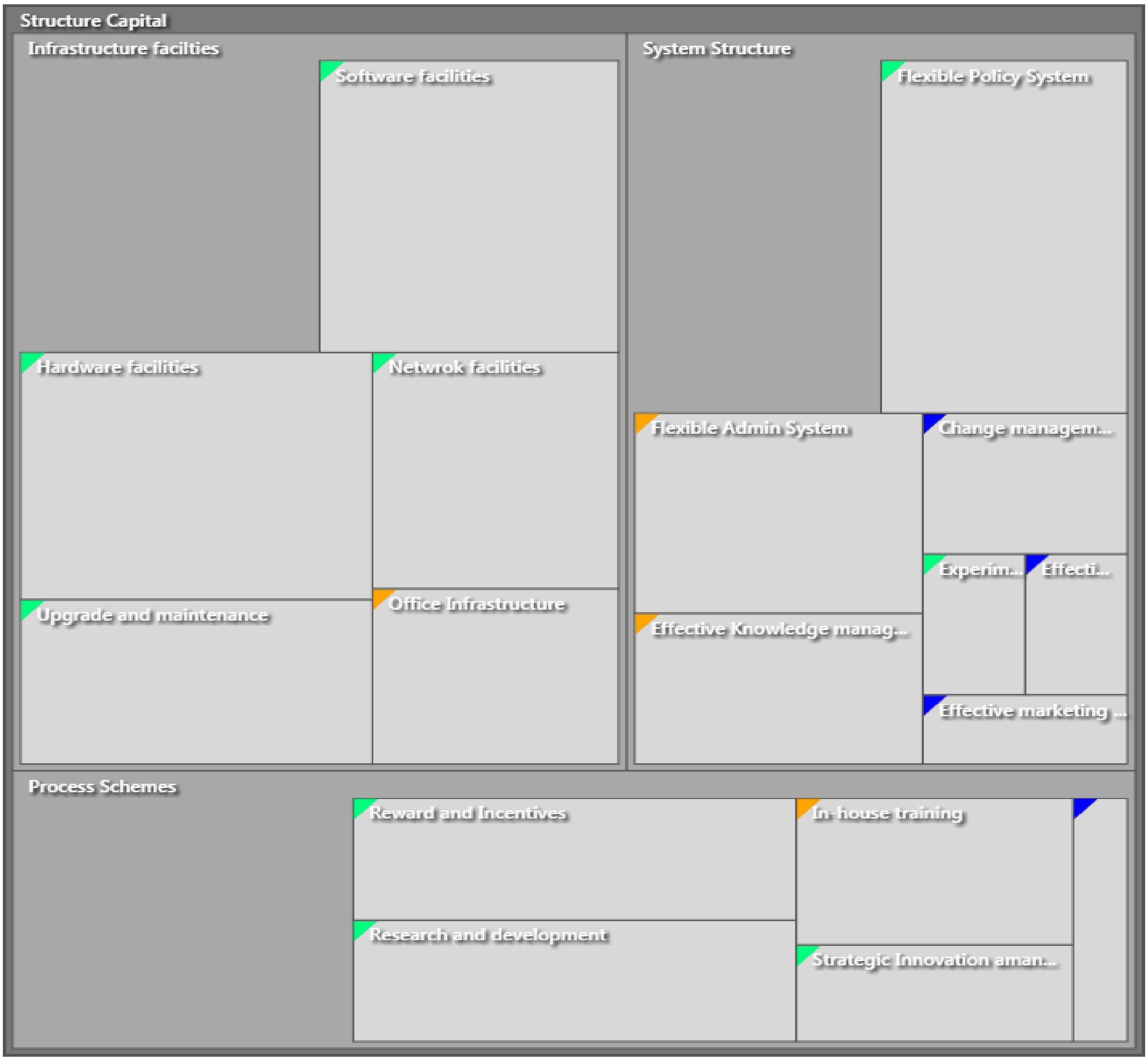
Number of comparisons	4
Number of participants	6
Consensus	74%
Consistency Ratio CR	0.37
GCI	0.06
Consistency Ratio CR	2%
Principal Eigen value	3.000
Eigenvector solution: 6 iterations, Thresh = 1E-07 , EVM check:= 1.2E-08	

Eigenvalue				lambda:	**4.048**
Consistency Ratio	0.37	GCI:	0.06	CR:	1.8%

The consolidated analysis, comprising the six case study participants, yields a 74% consensus with a consistency ratio of 0.37. The result indicates that the internal relationship components are the first priority within the RC, with a weight of 45%. This is followed by the external relationship components with 26% and the image and reputation components with 22%. The lowest priorities are the environmental relationship components with 7%, which could be attributed to the failure of the government to push for BIM adoption.

5.3.3 ANALYSIS OF THE SC ELEMENTS

This section presents the consolidated analysis of the SC elements of the case study, and involves two stages, which are the consolidated interview analysis using NVIVO software, and the consolidated interview analysis involving the pairwise comparison and using the normalised principal Eigenvector.



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Key:

Green: Indicators accepted by survey and confirmed by the case study analysis	**Orange:** Indicators identified by literature but only confirmed by Case study analysis	**Blue:** New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 23: Hierarchy chart, TreeMap, showing the analysis of the data triangulation based on the SC elements for all sources

The results suggest that each indicator noted within the survey results has a significant number of references within the case study analysis. Thus, under the capability and support components through the infrastructural facilities, the firms identify the importance of all the same indicators as the survey results. In addition, the study also identifies the office infrastructure indicator for BIM technology, which is acknowledged within the literature but not accepted by the survey study. Furthermore, within the capability and support components, the firms similarly identify all the indicators noted by the survey results. However, within the system structure of a firm, three new indicators are also acknowledged, which are: a change management system, an effective remuneration system, and an effective marketing strategy. These have a significant amount of references, as shown in Table 59. Furthermore, the firms note two other indicators, which are a flexible administrative system and an effective knowledge management system; these are identified within the literature but not accepted by the survey study.

Regarding the capability and support components of the firms' process and schemes driving BBVC, all the indicators provided by the survey result are also identified within the interviews. However, one new indicator is also noted, which is a regular coordination scheme and this has a significant amount of references, as shown in Figure 23. This is in addition to the in-house training scheme indicator, which is identified within the literature and by the firms but not accepted within the survey study. Generally, the findings are that the results provided by the survey study, regarding the SC elements, are established as reliable and valid for synthesis within the business model for BBVC.

Change management, despite its identification under the process aspect of the SC, has also been identified under the system structure, this shows its emphasis on the support and motivation it brings in the BIM adoption process. This finding is consistent with the study by Holzer (2015) who emphasised that, success in BIM adoption, is all about change facilitation and management.

5.3.3.1 CONSOLIDATED PAIRWISE COMPARISON ANALYSIS OF THE SC

This section presents the results of the consolidated analysis of the pairwise comparison using the normalised principal Eigenvector. The principal is based on the premise that the judgements of all six firms converge towards a common outcome with an acceptable level of consensus. Hence, the results presented here include all the details regarding the level of the consensus and the outcome of the SC.

Table 59: Matrix table for the normalised principal Eigenvector, showing the consolidated RWV for the SC components

Matrix	Systems	Infrastructure	Process	Normalised principal Eigenvector	
Systems	1.00	0.39	2.26	26%	
Infrastructure	2.58	1.00	4.52	62%	
Process	0.44	0.22	1.00	12%	

Number of comparisons	3
Number of participants	6
Consensus	84%
Consistency Ratio CR	0.8
GCI	0.02
Consistency Ratio CR	0.0%
Principal Eigen value	3.007
Eigenvector solution: 8 iterations, Thresh = 1E-07 , EVM check:= 1.5E-08	

Eigenvalue				lambda:	**3.007**
Consistency Ratio	0.37	GCI:	0.02	CR:	0.8%

The consolidated analysis comprising the six case study participants yield a 84% consensus with a consistency ratio of 0.8. The result indicates that the infrastructure components are the first SC priority with a weight of 62%. This is followed by the system structure components with 26%, and the lowest priority are the process and scheme components with 12%.

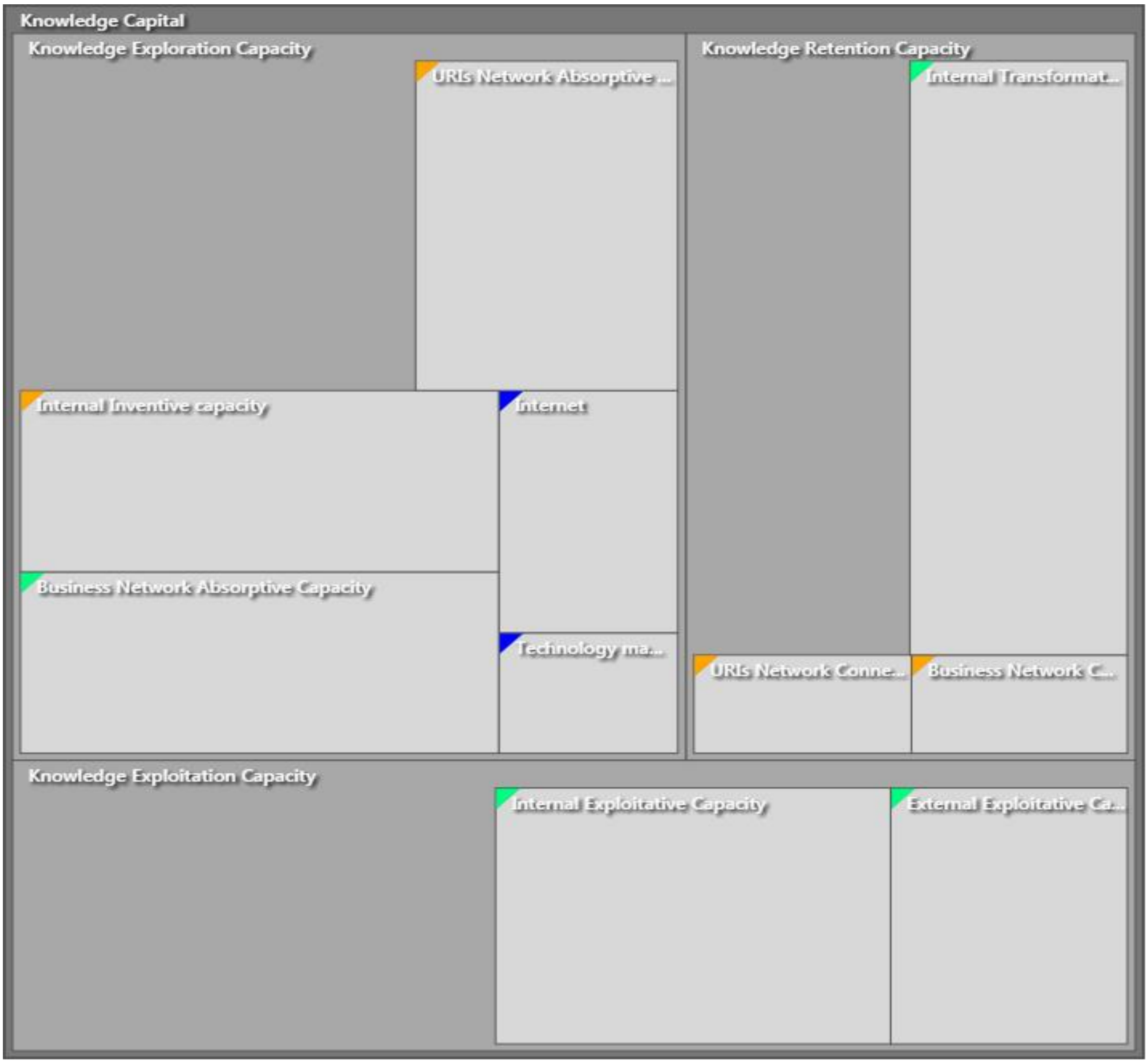
5.3.4 ANALYSIS OF THE KC ELEMENTS

This section presents the consolidated analysis of the KC elements of the case study. It involves two stages, which are the consolidated interview analysis using NVIVO software and the consolidated interview analysis through a pairwise comparison using the normalised principal Eigenvector.

5.3.4.1 CONSOLIDATED INTERVIEW ANALYSIS USING NVIVO SOFTWARE

This presents the result of the consolidated analysis regarding the KC elements and involves the consolidation of the interview analysis of the six architectural firms. The result is presented using TreeMap (Figure 24), which shows the amount of references coded per indicator for each component. The result suggests that each indicator noted by the survey results has a significant amount of references within the case study analysis.

Furthermore, under the knowledge exploration capacity components driving BBVC, the firms identify the importance of all the indicators provided by the survey result. In addition, the study also identifies the internal inventive capacity and URIs' network absorptive capacity indicators, which are noted within the literature but not accepted within the survey study. However, two other indicators are acknowledged, namely a flexible administrative system and an effective knowledge management system, which are identified through the literature but not accepted within the survey study. In addition, for the knowledge retention capacity components, the firms only identify the internal inventive capacity indicator, which also echoes the survey results. However, the analysis also identifies the business network connective capacity and URIs' network connective capacity indicators, which are acknowledged within the literature but not in the survey study. Finally, with regard to the knowledge exploitation capacity components, the firms similarly identify only two indicators, namely the internal and external exploitation capacities, and this echoes the survey results. Thus, in general, the findings indicate that the results provided by the survey study regarding the KC elements are established to be reliable and valid for synthesis within the business model for BBVC.



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Key:

Green: Indicators accepted by survey and confirmed by the case study analysis	**Orange:** Indicators identified by literature but only confirmed by Case study analysis	**Blue:** New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 24: Hierarchy chart, TreeMap, showing the analysis of the data triangulation based on the KC elements for all sources

5.3.4.2 CONSOLIDATED PAIRWISE COMPARISON ANALYSIS OF THE KC

This section presents the results of the consolidated analysis of the pairwise comparison, using the normalised principal Eigenvector. The principle is based on the premise that the judgements of all six firms converge toward a common outcome with an acceptable level of consensus. Hence, the results presented here (Table 60) include all the details regarding the level of the consensus and the outcome of the KC.

Table 60: Matrix table for the normalised principal Eigenvector showing the consolidated RWV for the KC components

Matrix	Exploration	Retention	Exploitation	**Normalised principal Eigenvector**	
Exploration	1.00	2.50	1.31	46%	
Retention	0.40	1.00	0.50	18%	
Exploitation	0.76	1.99	1.00	36%	

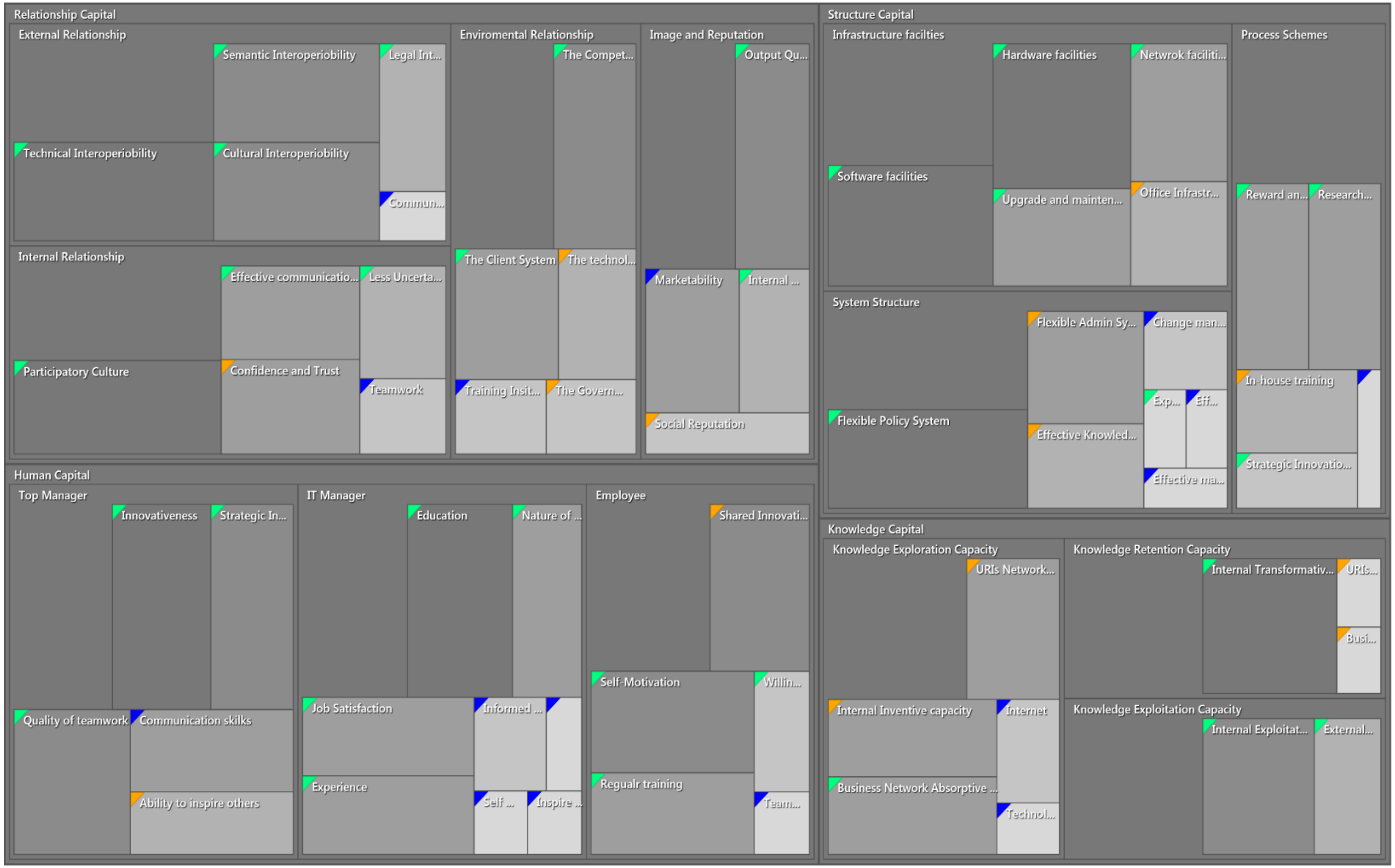
Number of comparisons	3
Number of participants	6
Consensus	72%
Consistency Ratio CR	0.37
GCI	0.00
Consistency Ratio CR	0.0%
Principal Eigen value	3.000
Eigenvector solution: 8 iterations, Thresh = 1E-070 , EVM check:= 2.1E-08	

Eigenvalue				lambda:	**3.000**	
Consistency Ratio	0.37	GCI:	0.00		CR:	0.0%

The consolidated analysis comprising the six case study participants yields a 72% consensus result with a consistency ratio of 0.37. The result indicates that the knowledge exploration capacity components are the first priority within the KC, with a weight of 46%. This is followed by the knowledge exploitation capacity components with 36%, whilst the lowest priorities are the process and scheme components, with 18%.

5.4 SUMMARY OF THE FINDINGS

This section identifies the ways in which the firms develop their IC for BBVC, and compares the case study and survey results. The results suggest that all the indicators that are identified through the survey study are also identified in the case study. This establishes the reliability and validity of the survey results. The outcome provides the basis of the synthesis stage. Furthermore, the results also suggest that some of the indicators initially identified within the literature review but not accepted by the survey study are nevertheless identified by the case study. As shown in orange in Figure 25, there are four such indicators under RC, two under HC, four under KC and three under SC. Some new indicators are also identified that are neither initially identified in the literature, nor in the survey. These indicators represented the strength of the case study approach, in that the method this allows for the introduction of alternatives not otherwise known. As shown in blue in Figure 25, there are four such indicators under RC, six under HC, two under KC, and four under SC.



Green: Indicators accepted by survey and confirmed by the case study analysis

Orange: Indicators identified by literature but only confirmed by Case study

Blue: New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Generated by NVIVO 11 Software

Figure 25: Hierarchy chart, TreeMap, showing the consolidated analysis of the data triangulation based on all IC elements for all sources

5.4.1 THE RWV OF THE FOUR IC CAPITALS

This section presents the results of the consolidated analysis of the pairwise comparison, using the normalised principal Eigenvector, at the capital level. The result represents the RWV for each of the four capitals and their effect on the BBVC.

Table 61: Matrix table for the normalised principal Eigenvector showing the consolidated RWV value for the four (IC) Capitals

Matrix	HC	RC	SC	KC	**Normalised principal Eigenvector**	
HC	1.00	2.61	2.43	5.92	50%	
RC	0.38	1.00	1.10	2.61	21%	
SC	0.41	0.91	1.00	3.71	22%	
KC	0.17	0.38	0.27	1.00	7%	

Eigenvalue				lambda:	**4.027**
Consistency Ratio	~~0.37~~	GCI:	0.04	CR:	1.0%

Consensus	82%
Consistency Ratio CR	0.37
GCI	0.00
Consistency Ratio CR	1.0%
Principal Eigen value	4.027
Eigenvector solution: 6 iterations, Thresh = 1E-070 , EVM check:= 1.5E-08	

The results in Table 61 suggest that, in general, HC is considered to have the greater weighting, at 50%, and is followed by SC and RC with 22% and 21% respectively. Meanwhile, KC is considered to have the lowest RWV value at 7%.

5.4.2 SUMMARY OF THE PAIRWISE COMPARISON ANALYSIS

Table 62: Summary of the findings for the RWV of all four Capitals and their components

THE FOUR CAPITALS IN ASCENDING PRIORITY		THE COMPONENTS IN EACH CAPITAL IN ASCENDING PRIORITY		
The Capitals	Percentage Priority	The Components	Percentage Priority	
HC	50%	IT manager	42%	1
		Top manager	34%	2
		Employees	24%	3
SC	22%	Infrastructure	62%	1
		Systems	26%	2
		Process	12%	3
RC	21%	Internal Relationship	45%	1
		External Relationship	26%	2
		Image and Reputation	22%	3
		Environmental Relationship	7%	4
KC	7%	Exploration	46%	1
		Exploitation	36%	2
		Retention	18%	3

Table 63: Details of the normalised principal Eigenvector for the six firms, based on all IC Capitals and components

	HC SET	SC SET	RC SET	KC SET	SET OF THE FOUR IC ASPECTS
Number of comparisons	3	3	6	3	6
Number of participants	6	6	6	6	6
a:	0.1	0.1	0.1	0.1	0.1
Consensus	66%	84%	74%	72	82%
Consistency Ratio	0.37	0.8	0.37	0.37	0.37
GCI	0.00	0.02	0.06	0.00	0.00
CR	0.0%	0.0%	1.8%	0.0%	1.0%
Principal Eigenvalue	3.000	3.007	3.000	3.000	4.027
Eigenvector solution:	8 iterations, Thresh = 1E-070 , EVM check:= 2.5E-08	8 iterations, Thresh = 1E-07 , EVM check:= 1.5E-08	6 iterations, Thresh = 1E-07 , EVM check:= 1.2E-08	8 iterations, Thresh = 1E-070 , EVM check:= 2.1E-08	6 iterations, Thresh = 1E-070 , EVM check:= 1.5E-08

Table 62 presents the summary of the consolidated pairwise comparison results. The table depicts the RWV of the different IC elements of the components level, and the four IC aspects. Subsequently, Table 63 presents the details of the consolidated normalised principal Eigenvector for the six firms on their consensus, consistency ratio and some important details. The result suggests that, in general, the HC is considered to have the greatest weight at 50%, which is followed, by SC and RC with 22% and 21% respectively. Meanwhile, KC is considered to have the lowest RWV value of 7%. The results also show the different weight within the component sets of the four capitals. For example: the motivation and capability of the IT manager is the most important component of HC; the support and capability of the infrastructure under SC; the network resource resulting from internal relationships under RC; and the knowledge exploration capacity under KC.

5.5 CHAPTER SUMMARY

This chapter presented the case study analysis of the study. Six SME architectural firms were selected and interviewed based on their relatively higher capability on BIM adoption process. The data from the interview forms the basis of the case study analysis in this chapter. The analysis was approached in two ways: firstly, an exploratory study using a semi-structured interview based on the thirteen components of the Intellectual Capitals identified through the literature review. The analysis helped to identify the different indicators employed by the six architectural firms during BBVC. The analysis of these data was conducted using the NVIVO software through thematic analysis. The outcome were presented using Treemap analysis produced by the NVIVO software. Secondly, the Eigenvector method was used to analyse a pairwise comparison judgement where each of the components discussed in the interview was compared and weighted in terms of their relative importance. The outcome helped to establish the survey data's reliability and validity as well as provide the relative weighting value of the thirteen components and the four IC aspects.

6 CHAPTER SIX: SYNTHESIS AND VALIDATION OF THE STRATEGIC BUSINESS MODEL (SBM) FOR BIM-BASED INNOVATION

6.1 CHAPTER OVERVIEW

The chapter presents a synthesis of the study in order to develop the Strategic Business Model (SBM) using the Intellectual Capitals and components identified through the study. In the previous chapters, an evaluation framework has been developed to collect data from the Nigerian context. The essence of this data is to develop a viable business model to explain how the development of IC in SME architectural firms affects BBVC. In this chapter, this data are now to be used to develop a Strategic Business Model to this effect. The chapter uses the data from all the analysis conducted to develop the model and involves the use of an Analytical Hierarchy Process Model to develop the SBM. The model presents a practical strategic focus that firms can adopt in order to efficiently manage their IC for BBVC. The model, made for practice, is then shared with a focus group for validation purposes. The outcome of the focus group, which is presented at the end of this chapter, outlines the practical implications of the study.

6.2 SBM DEVELOPMENT

The Strategic Business Model (SBM) is the proposed model to be developed by the study in this chapter and it is intended to serve as a viable business case in helping firms to manage and evaluate their intellectual capital development toward BIM Business Value creation. The development involves the following four main stages, as follows;

1. Structuring the model to fit the main goal of the study; this is achieved through applying the AHP Model
2. Establishing the AHP Model by inputting the Relative Weighing Value of all the IC elements, using the result of the analyses already conducted.
3. Developing a clear visual map that describes the AHP model
4. Developing a SBM that shows areas of focus in the development of the IC elements for BBVC.

6.2.1 AHP METHOD

The Analytic Hierarchy Process (AHP) (Saaty, 2008) is a multi-criteria decision-making approach. The process serves as a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub criteria, and alternatives. The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. It involves breaking down a complex problem and then combining the solutions. It is broadly acknowledged that the AHP method is one of the best methodologies for prioritising various indicators (Costa & Ramos, 2015). Furthermore, the application of the AHP approach needs only a small number of respondents with experience and knowledge (Kim & Kumar, 2009). The AHP methodology complies particularly well with the goal of this study. This is because, when developing a methodological proposal to manage the IC elements in a BIM innovation context, besides listing and classifying a firm's intellectual elements, it is equally important to hierarchise them. This means identifying those that have a greater potential impact on the organisation's strategic goal. The AHP model enables the proactive participation of firm managers in identifying areas of paramount importance. Furthermore, it enables firms to identify the specific areas of the organisation that demand particular attention, and determine the IC elements that need to be subject to more careful and urgent analysis (Costa & Ramos, 2015). Thus, the basic principle of the AHP method lies in analysing several alternatives from different criteria. As such, a hierarchy is built in which, at the top, lies the problem for consideration (Kim & Kumar, 2009). The next layer consists of the criteria, or strategies for consideration, and the last layer resides in several alternative activities or actions.

6.2.2 ESTABLISHING THE AHP MODEL

In establishing the AHP model for this study, the hierarchy is a structured as a means of modelling the relative weight of the different IC elements in forming BBVC. It consists of four levels, an overall goal, the four IC aspects, their components, and the indicators that define them. The data for the AHP model are all derived from the study's result.

- ❑ First level: Organizational goal, which is BBVC

The first step in an AHP analysis is to build a hierarchy for the decision. This is also called decision modelling and it simply consists of building a hierarchy to analyse the decision. The analytic hierarchy process (AHP) structures the problem as a hierarchy which in this case is the developing a Strategic Business model for BBVC.

- ❑ Second level: The four aspects of IC (results from the pairwise comparison from the case study)

It is then essential to breakdown the problem into as many necessary factor that contributes to its solution which thereof forms the second level in the hierarchy. For this study, based on the findings of the study, the four aspects of the IC development which are the HC, SC, RC and KC forms the factors that directly contributes to the BBVC. This result from the pairwise comparison from the case study gives the level of influence each of this four aspects of the IC development contributes to the first level.

- ❑ Third level: The 13 components under the four IC Capitals (results from the pairwise comparison from the case study)

The third level consists of the available alternatives for each of the criteria which are the various components of the four capitals. The advantages of this hierarchical decomposition are clear. By structuring the problem in this way it is possible to better understand the decision to be achieved, the criteria to be used and the alternatives to be evaluated. This step is crucial and this is where, in more complex problems, it is possible to request the participation of experts to ensure that all criteria and possible alternatives have been considered.

- ❑ Fourth level: The Indicators

The forth level is consist of the various steps to achieve those alternatives in the third level. The indicators that define the components. The results from the multiple regression analysis of the survey results, which are reinforced by the exploratory case study spells out the level of influence each of this indicators contributes within its set under particular components.

6.2.2.1 THE FIRST LEVEL (ORGANISATIONAL GOALS)

The first level of the proposed hierarchical structure encompasses the organisation’s goal, which in this study means maximising BBVC through the identification and management of critical IC elements.

6.2.2.2 THE SECOND LEVEL (THE FOUR CAPITALS ELEMENTS)

The second level variables are the four basic IC capitals (Human, Structure, Relationship and Knowledge), as essential drivers of BBVC. The relative weighting value of these variables are derived from the results of the pairwise comparison test, presented in Chapter Five and shown in Figure 26.

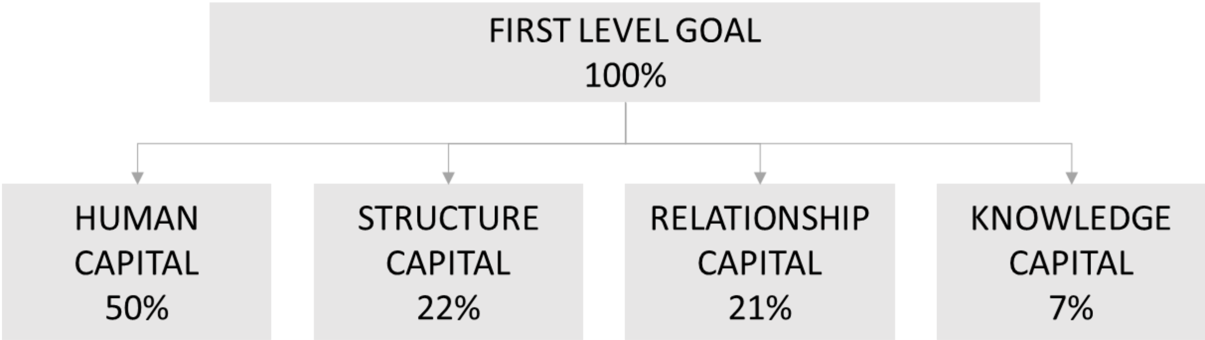


Figure 26: Second Level of the AHP model for BIM-based innovation

The AHP at the second level suggests that, for BBVC to occur, 50% of firms' organisational goals are predominantly formed through developing the motivation and capability of their HC. The rest are formed through support and capability from their SC (22%), motivation and network resources from their RC (21%), and through resource management of their KC (7%).

6.2.2.3 THE THIRD LEVEL (THE CRITICAL COMPONENTS)

The third level variables are the set of components that form each of the four basic IC capitals. The relative weighing value for these variables are derived from the pairwise comparison test results presented in Chapter Five, and shown in Figure 27.

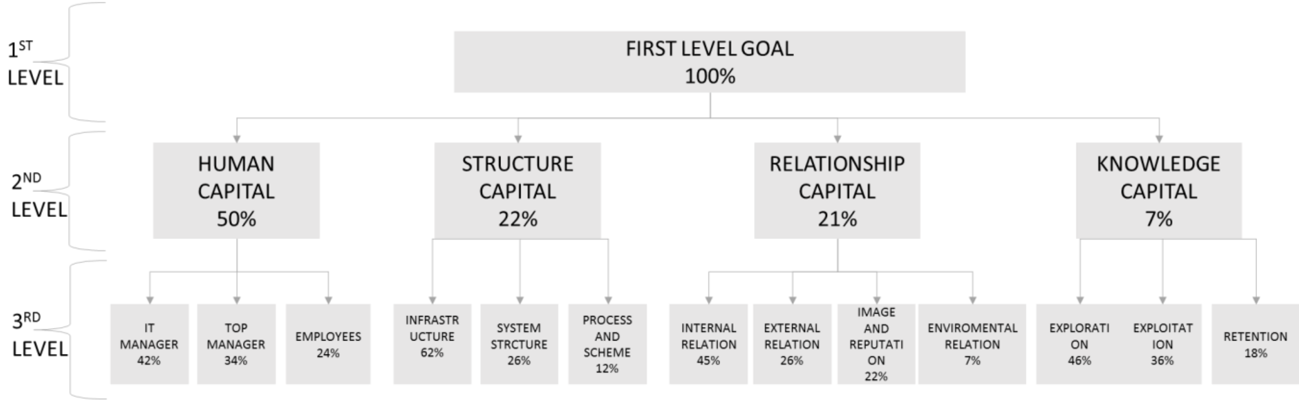


Figure 27: Third Level AHP model for BIM-based innovation

The AHP at the third level provides a further breakdown of the second level through providing the criteria that form each of the four IC Capitals. Firstly, for HC, which forms the 50% of the first level organisational goal, the IT manager forms 42% whilst the top manager forms 34%, and employees form 24%. Secondly, for SC, which forms the 22% of the first level organisational goal, the infrastructural facilities forms 62%, the system structure forms 26%, and the process scheme forms the remaining 12%. Thirdly, for RC, which comprises 21% of the first level organisational goal, the internal relationships form 45%, the external relationships form 26%, the image and reputation form 22%, and the environmental relationships form the remaining 7%. Finally, for the KC, which comprise 7% of the first level organisational goal, the knowledge exploration capacity forms 46%, the knowledge exploitation capacity forms 36%, and the knowledge retention capacity forms the remaining 18%

6.2.2.4 THE FOURTH LEVEL (THE INDICATORS)

This level is the most critical level of the AHP as it describes the practical indicators that form the development of the IC. In this level, a set of indicators is grouped under each component to define the practical steps that need to be taken into consideration when developing the IC of the BBVC. The relative weighting value on this level is provided by the multiple regression analysis in Chapter Four, which is triangulated with the case study analysis in Chapter Five to establish the reliability and validity of the data.

Table 64: The AHP model hierarchy: Critical elements for BIM-based innovation

1st Level: organisation's goal **Maximising BBVC through the identification and management of critical IC elements**						
2nd Level: The Four IC Elements		3rd Level: The Components Sets of the IC		4th level: Specific Indicators That Define The Various Component Sets Of The IC		
The Capitals	% by Priority	The Components	% by Priority	The Indicators	Beta Weight (multiple regression)	% by priority
HUMAN CAPITAL (HC)	**50%**	IT manager	42%	The IT managers has higher job satisfaction	0.432	33%
				The IT managers has higher education qualification	0.425	32%
				The IT managers is on permanent basis	0.285	22%
				The IT manager previous IT experience.	0.178	13%
		Top manager	34%	The quality of teamwork	0.403	50%
				Non-resistance to change	0.219	27%
				Strategic knowledge of innovation	0.180	22%
		Employee	24%	Employees with self-motivations	0.525	44%
				Employees with regular training	0.452	38%
				Employees with willingness to accept innovation	0.218	18%
STURCTURE CAPITAL (SC)	**22%**	Infrastructure	62%	Availability of maintenance and upgrade facilities for technology.	0.407	35%
				Availability of digital hardware facilities	0.261	23%
				Availability of network facilities	0.246	21%
				Availability of digital software facilities	0.236	21%
		Systems	26%	Flexible policy system for innovation	0.446	62%
				System for experimentation culture	0.279	38%
		Process	12%	Reward and incentive schemes for innovation	0.380	41%
				Strategic innovation management schemes	0.351	38%
				Research and development schemes	0.201	22%

1st Level: organisation's goal Maximising BBVC through the identification and management of critical IC elements						
2nd Level: The Four IC Elements		3rd Level: The Components Sets of the IC		4th level: Specific Indicators That Define The Various Component Sets Of The IC		
The Capitals	% by Priority	The Components	% by Priority	The Indicators	Beta Weight (multiple regression)	% by priority
RELATIONSHIP CAPITAL (RC)	**21%**	Internal relationship	45%	Internal relationship of participative culture	0.307	42%
				Internal relationship of efficient communication flow	0.235	32%
				Internal relationship of less uncertainty avoidance	0.196	27%
		External relationship	26%	Legal interoperability	0.439	33%
				Technical interoperability	0.336	25%
				Cultural interoperability	0.327	24%
				Semantic interoperability	0.236	18%
		Image and reputation	22%	Functionality (outcome of BIM quality)	0.464	71%
				Subjective dimensions (employees' external perceptions)	0.188	29%
		Environmental relationship	7%	The client system in the innovative environment	0.602	74%
				The competitiveness in the innovative environment	0.214	26%
KNOWLEDGE CAPITAL (KC)	**7%**	Exploration	46%	Business network absorptive capacity	0.533	100%
		Exploitation	35%	Internal exploitation capacity	0.592	78%
				External exploitation capacity	0.164	22%
		Retention	18%	Internal transformative capacity	0.535	100%

Table 64 shows the relative weighting values at the fourth and the final level of the AHP model. The result suggests that the development of HC to form BBVC occurs through the motivation and capability of the IT manager, top manager and employees. For the IT manager, the key elements include: work flexibility, educational attainment, previous IT experience and job satisfaction. For the top manager, it includes: strategic knowledge of innovation, non-resistance to change, and the quality of teamwork. Meanwhile for employees, it includes regular training, a willingness to accept innovation, and self-motivation.

The development of SC to form BBVC occurs through the support and capability of their infrastructural facilities, the system structure of the firm, and the different process and schemes in place for innovation. Infrastructure indicators for the facilities include: the hardware, software, and network, as well as ensuring the continued maintenance and upgrade of all facilities. The system structure includes a flexible policy system to accommodate innovative ideas and systems that allows for the experimentation of ideas. It also involves process and schemes, including rewards and incentives, strategic innovation management, and research and development.

The development of RC to form BBVC occurs through the motivation and network resource resulting from the internal, external relationship, and environmental relationship, along with the image and reputation. The internal relationship includes an efficient communication flow, a participative culture, and less uncertainty avoidance within the firm's social unit. The external relationships include the interoperability of the firm to operate with its external partners based on technical, semantic, cultural and legal dimensions. Image and reputation includes the BIM quality outcome and the subjective employees' perceptions. The environmental relationship includes the client system and the competitiveness of the innovation environment.

Finally, the development of KC to create the BIM business value occurs through the capacity of the firm to manage their knowledge exploration capacity, knowledge exploitation capacity, and knowledge retention capacity. For the knowledge exploratory capacity, this includes the business network's absorptive capacity, whilst for the knowledge exploitation capacity, it includes the internal and external exploitation capacities. Lastly, for the knowledge retention capacity, it includes the internal transformative capacity.

6.2.3 VISUAL MAP OF THE ESTABLISHED AHP MODEL

The AHP concept map depicts the visual hierarchy of all the critical IC elements, as discussed in the previous sections. The map can help firms evaluate their IC and provide alternatives to maximise their potential.

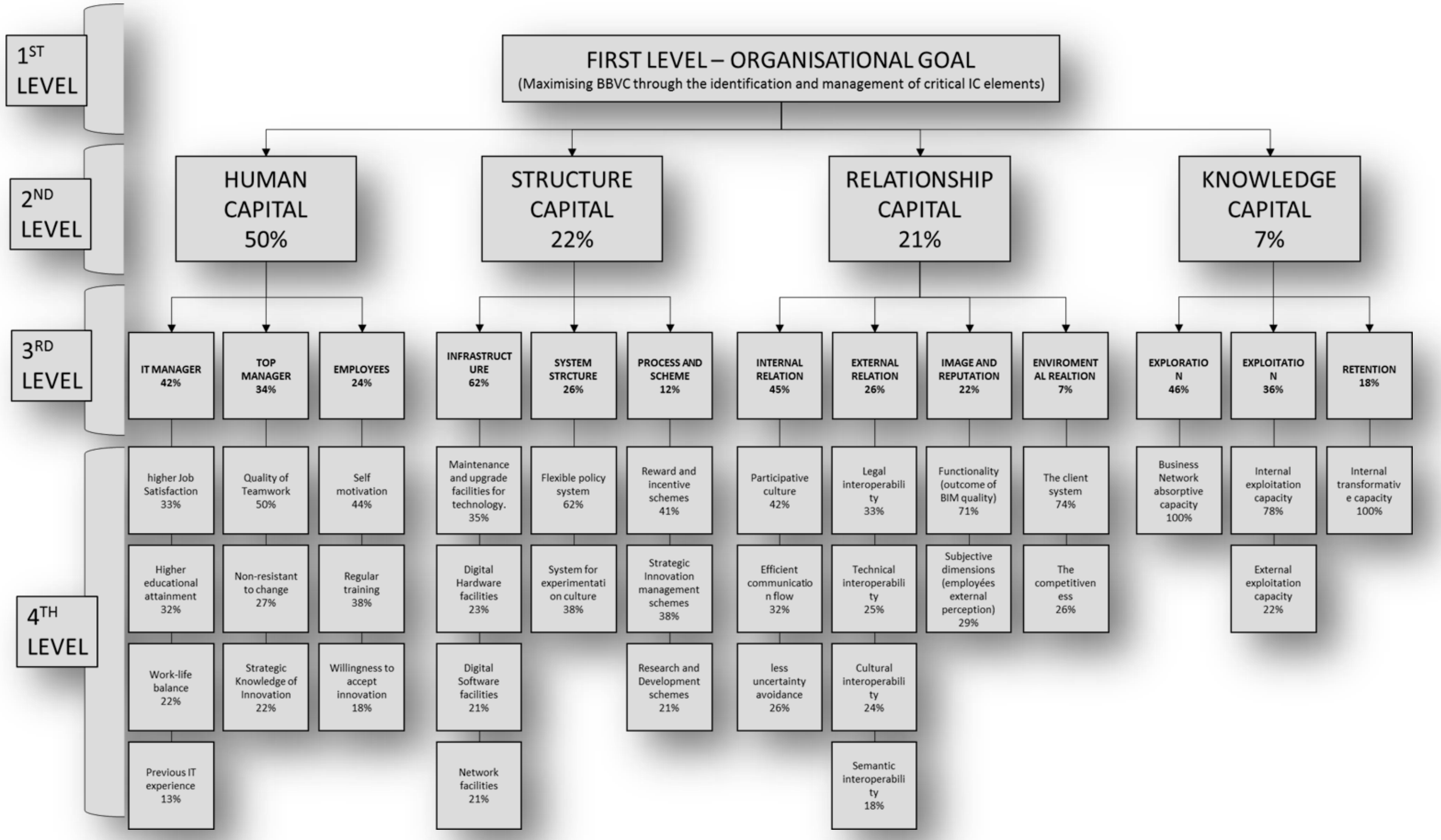


Figure 28: Visual map of the established AHP model for BIM-based innovation

Key: 1st Level: Organisation goal - maximising and optimising BIM adoption through the management and optimisation of the firm's IC

2nd Level: The four capitals of the IC

3rd level: The four capitals' sets of components

4th level: The indicators that define the IC components

From Figure 28, it can be seen that the motivation and capability of HC in SME architectural firms are considered the most important IC elements contributing to BBVC organisational goals. In contrast, the resource management of the KC element is ranked as the least important. Furthermore, the IT manager component is the most important part of the HC, whilst the infrastructure facilities are the highest ranking within the SC, and the internal relationships are the highest ranking of the RC, and so on.

6.2.4 THE STRATEGIC BUSINESS MODEL (SBM) OF INTELLECTUAL CAPITAL DEVELOPMENT OF SME ARCHITECTURAL FIRMS TOWARD BIM BUSINESS VALUE CREATION (BBVC).

The goal at this stage of the study is to use the outcome to provide SME architectural firms with an SBM tool that describes a clear focus area of priority to manage their IC and thus optimise their BBVC. The use of a focus area of priority in developing a business model for firms has well been established in the literature (Kim & Kumar, 2009; Goepel, 2013b; Costa & Ramos, 2015). In this context, three focus areas are used to describe the priorities when optimising BBVC through IC.

(1) Core focus area: refers to the highest and primary priority aspect of a given IC elements HC, SC, RC and KC.

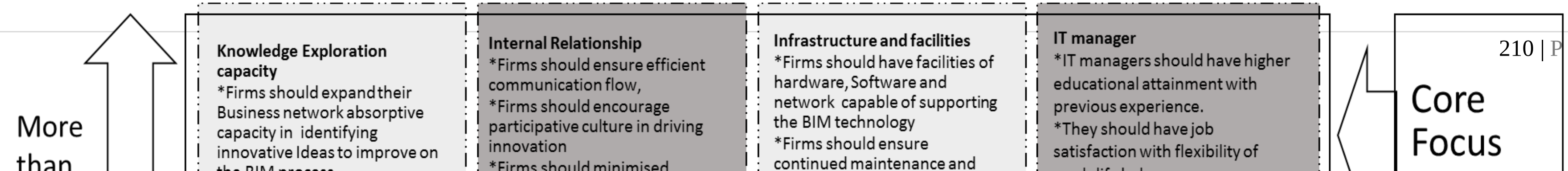
(2) General focus area: refers to the secondary priority aspect of a given IC elements HC, SC, RC and KC.

and

(3) Potential focus area: refers to the basic aspect of a given IC elements HC, SC, RC and KC.

The goal of using a focus area of priority to describe the business model is to identify the core improvement area, in which some aspects should be developed before others, and taking into consideration limited resources (Kim & Kumar, 2009). On the basis of the AHP analysis results, the indicators (which form the recommendations under the different IC components) are grouped into three horizontal areas, as shown in Figure 29. The top horizontal cell which is referred to as the Core Focus area in the figure notes that this is the most significant area to drive the maximum BBVC and these are the components of the IC elements that have RWV of more than 40%. For SME architectural firms, therefore, this represents the spotlight for available resources in developing the Intellectual Capital. The middle cells which is general focus area are those components with 20% to 40% RWV and the bottom cells which are the potential focus area are those below 20%. On the other hand, the prioritisation of the four IC aspects is shown vertically, starting from the less essential (the KC elements) which has 7% RWV within the hierarchy of the four IC elements, followed by the essential (the SC and RC elements) with RWV of above 20% to the highest (the HC aspect) with RWV of 50%.

Figure 29: Strategic Business Model (SBM) of Intellectual Capital Development of SME Architectural Firms toward BIM Business Value Creation (BBVC)



From the SBM (Figure 29), it is therefore possible to determine which areas of the IC development should be developed and in which manner in the short- and long-term. For example, in the top cell (the core focus area), it can be seen that the manner of developing the IC aspect in HC is through developing the motivation and capability of the IT manager (in HC) which the core focus area for maximising BBVC. This can be achieved through ensuring that the IT manager's educational attainment and previous experience is considered when recruiting for a BIM technology role. Also, after the recruitment, the firm should address the job satisfaction of the IT manager, and allow for flexibility in their work-life balance, as this is believed to boost their awareness and creativity for innovation. The empty box on the bottom right side of the model depicts that, under HC cells, all components are either general focus or core focus areas, and there is no room for any potential area. This shows how important the HC aspect is in developing the BBVC. On the other hand, in the lowest cell, the potential focus area indicates that, when developing capability and support within their SC, firms should initiate rewards and incentives schemes to motivate employees. They should ensure that the establishment of innovation management schemes for performance metrics, and set up research and development schemes. In this respect, the map enables firms to understand how to appropriately invest their limited resources and activities to achieve an efficient IC management for BBVC.

6.3 VALIDATION OF THE STRATEGIC BUSINESS MODEL (SBM)

This section presents the validation process of the SBM developed for the study. This is necessary because the development process of the SBM presented in the previous sections can be regarded as theoretical for the practice. Hence, there is a need to evaluate its validity before it can be more widely disseminated (Apulu, 2012). The aim of the validation process is to determine whether the claim of the SBM is sound and reliable. Validation is vital because it reveals the potential objectivity and reliability of the research (Apulu, 2012). The following section provides a general discussion of the concept of validation for the SBM development and then the method adopted for undertaking the validation exercise. Subsequently, the details involved in each of the validation procedures are discussed.

6.3.1 THE CONCEPT OF VALIDATION

Validation is integral to the SBM development process in ensuring confidence in its assertions and recommendations and makes it more valuable (Kennedy et al, 2005). Validation determines whether the claim of the SBM truly represents what it was intended to measure or how truthful the research results represent the claim (Golafshani, 2003). It is the process of confirming whether the proposed SBM is appropriate, especially in the light of the Usefulness and implementability (Frees, 1996) . This process attempts to ensure that the SBM represents the characteristics of the general population and is not peculiar to the samples used in its estimation (Hair et al, 1998).

6.3.2 THE VALIDATION CRITERIA.

The purpose of validation process depends on the satisfaction of certain criteria set by a study, which can be informed by the research objective (Kocatürk, 2006). In this study, the objective is to develop a viable business model that can enable SME architectural practices in emerging markets to manage and evaluate their IC development. Therefore, it is important to establish criteria that can be practical as possible in achieving this objective.

According to Kocatürk (2006), validation criteria is dependent on the intended users and context of the theoretical and practical output of the research and can be based on the following four aspects, as follows:

- The model/theory should fit the substantive data (fit)
- The model/theory is applicable in variety of context (generality)
- The model/theory should be comprehensible to all involved in the area of study (relevance)
- The model/theory should anticipate possible confounding variables that may be brought up by the challenges to the theory; thus, it should be modifiable (modifiability).

In another context, a similar but more pragmatic approach by Kiviniemi (2005) developed at Stanford University suggested three criteria for validation of a requirement model specification which is relevant to this study. These criteria are generality, usefulness and implementability. Kiviniemi (2005) suggested that there is no objective method to measure or validate the usefulness or generality of a conceptual model. Particularly similar to that of the SBM where there is no or little existence prior knowledge on its operation. However, despite that, his approach is that a pragmatic process and can be involved. This makes it relevant as the SBM focuses on the practical value of the research.

Given the above, this study formulates its criteria in accordance with the Kiviniemi (2005) three criteria while contextualising it to fit the research objective. These are as follows:

- Generality: refers to the ability of the proposed model to fit the criteria to which the practical output of the research applies to variety of context intended by the study (Kocatürk, 2006)
- Usefulness: refers to the ability of the model to serve its intended use with ease (Kiviniemi, 2005).
- Implementability : refers to the ability of the proposed model to be implemented for the intended purpose (Kiviniemi, 2005) and whether it can be deployed by the intended stakeholders practically.

In the following sections, the methods involved in the validation process is presented. Subsequently, a detailed discussion of how these above criteria are used to achieve the validation process of the SBM is presented.

6.3.3 METHOD OF VALIDATION

The study ensured several steps while conducting the empirical study to achieve internal validation to its outcome. However, because of the pragmatic approach to the research which deals with practical implementation of the BIM innovation within the context of Nigeria, there is need to consider some of the practical credibility of the SBM validity. As a result, the study returned to the field to gather further information. In doing so, due to time and resource constraints, the study chooses the method of the focus group study with experts from the industry where the study was carried out. This is appropriate because, such participants can best comprehend the SBM, which is focused toward policy aspect. The participants are chosen from various backgrounds involving two policy makers, three heads of architectural firms at different levels of BIM adoption, one structural engineer, one quantity surveyor, and one client, all of whom are familiar with BIM adoption.

The focus group study took place in Abuja, the capital city of Nigeria. A conference room was prepared where all the participants were accommodated for the one-hour session. The session was divided into three stages. The first stage involved the introduction of the session and presentation of the SBM and validation process including the criteria involved in the study. This took about 15 minutes, and it allowed the participants to become familiar with the study. In the second stage, participants were given time to study the SBM for about a further 20 minutes. In the third stage, the session was opened for discussion, based on the three predetermined validation criteria. In each theme, the study moderated and recorded the discussion, and concluded only through a consensus amongst all participants. At the end of this session, the conclusion similarly was drawn. The report presented in this section is the outcome of the conclusion.

6.3.4 RESULTS OF THE FOCUS GROUP STUDY

This section provides with the process of achieving the validation process based on the three criteria through the methods adopted in the process.

On Generality as described by Kocatürk (2006) is the criteria to which the practical output of the research applies to variety of context intended by the study. The study intended to cover emerging markets, which have similar characteristics to the Nigerian context, where the sample is taken from. However, Yin (2003) argued that the data can still apply to the other emerging countries with some caution. The SBM model can easily be regarded valid for this particular case because, the data collected is based on multiple methods, which included the survey method. The survey method is believed to be the appropriate method in ensuring generality of study outcome (Yin, 2003).

On Usefulness, as in the case of intended users, the study presented the process of its validations to the focus group experts in the industry. In the report, one of the areas of contention on this criteria is the fact that the data collected is only from architectural firms, whereas the concept of the IC development can better be comprehended through the various stakeholders involved in the BIM process. While there is an agreement that, because of this reason, the claim of the SBM is largely a reflection of the cultures within the discipline of Architecture, there is a consensus that the methodology of the model is clear and it can be easily understood, modified and managed for other disciplines. The structural engineer and the quantity surveyor both acknowledged the model's importance and relevance to the entire industry and recommended that a similar study using data from their contexts could also yield a positive impact in tackling the identified issue.

One of the participants commenting on the categorisation of the focus area stated, *"…Ultimately, I believe, it clear that prioritising intangible elements and identifying critical improvement areas can be key to mobilise IC management in forming BBVC efficiently …*"

The participants reached a consensus that the strategy of prioritising has proven the usefulness of the model for its intended purpose.

On Implementability, which relates to the criteria of whether the SBM is possible to implement (Kiviniemi, 2005) and whether it can be deployed by the intended stakeholders. This is demonstrated through the involvement of participants from various backgrounds in the focus group, including policy makers (who can deliberate on the policy implications of the model), clients, and the heads of the firms at different levels of BIM adoption.

The stakeholders, particularly the heads of the architectural firms, affirmed that the model is clearly and practically communicated, well-articulated and developed thoroughly. The modus operandi is clear, and understandable without significant difficulty. The management of the IC in SME architectural firms is well within the control of every firm, and the implementation of this model can easily be achieved through a proper evaluation of the strategic planning of the firm. This is in line with the proposition of the study that, even if the individual abilities of the SME architectural firms to mobilise resources for effective BIM implementation are relatively small, the strategic decisions regarding their orientation towards IC development right under their control, and can be major catalysts for BIM success (Kim & Kumar, 2009) .

On limitations of the SBM, there was a concern about the confusion for the use of numbers in demonstrating the extent of importance in the elements of the Intellectual Capitals. The concern is that they make the model look theoretical; a need for the more literal meaning of figures is suggested to be useful in understating of the model. Consequently, this has been used to validate the final model. This is achieved through interpreting the percentages in more literal terms. On the Horizontal cascade, the Knowledge Capital aspect is now considered as less essential, the RC and SC capital aspect is now considered as essential, while the HC aspect is considered as most essential. Figure 30 is now the final calibrated SBM model for the study.

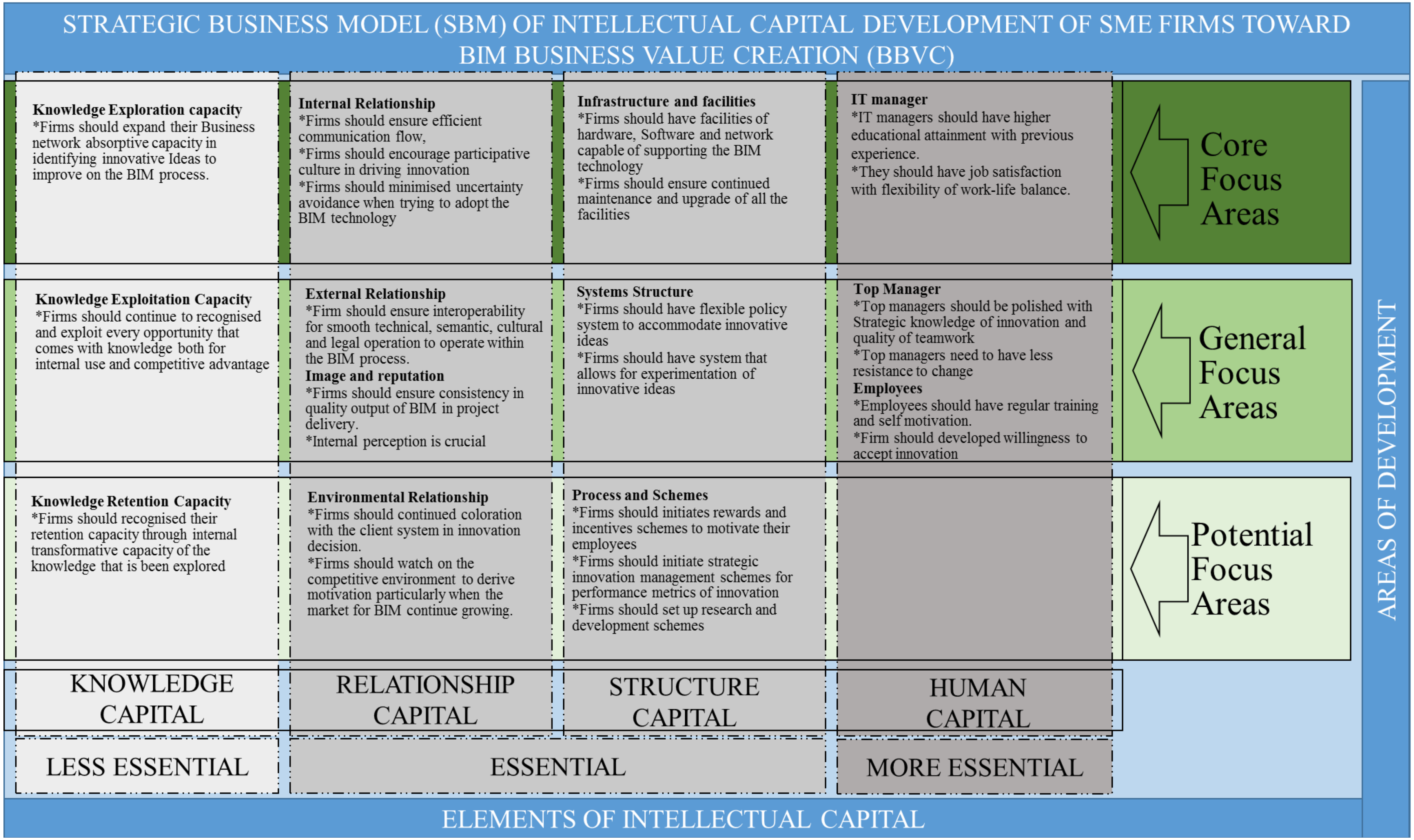


Figure 30: Final Strategic Business Model (SBM) of Intellectual Capital Development of SME Architectural Firms toward BIM Business Value Creation (BBVC)

6.4 CHAPTER SUMMARY

In this chapter, the development stage of the study is achieved through synthesis of a Strategic Business Model (SBM). The results and findings from the various analyses conducted from the study enabled the synthesis of SBM. This synthesis involved using the Analytical Hierarchy Process (AHP) concept. The SBM depicts the prioritisation of the IC elements, based on the following four levels; Indicator, Component, Capital and Organisation Goal. The SBM enables the practitioners to manage, prioritise and optimise their IC amidst limited resources through identification and evaluation of focus area of development. Through a focus group with experts from the industry, the SBM is validated practically on three criteria, namely; implementability, usefulness and generality. The feedback is used to validate the model and describe its practical implications.

7 CHAPTER SEVEN: SUMMARY AND CONCLUSION

7.1 CHAPTER OVERVIEW

This chapter presents the summary and conclusion aspect of the study. It includes discussion on the attainment of the four objectives of the study through the various analyses conducted. Subsequently, discussion on the intellectual merits of the study and its practical significance is presented together with its deductions and limitation.

7.2 SUMMARY OF THE THESIS

BIM has solidified its position in bringing efficiency in the AEC industry; however, the shift to its adoption and implementation in the emerging markets has brought distortion in both business processes and environments for Small and Medium Enterprise (SME architectural) firms in the industry. This has resulted in a lack of BIM Business Value Creation (BBVC) for such firms. This study is built on a premise of the theories of Intellectual Capital (IC); these theories approach BIM adoption in SME architectural firms as a knowledge based innovation, which occurs with the development of Human, Relationship and Structure Capitals which are integrated to form Knowledge Capital. These capitals are crucial for the business processes and success of SME architectural firms. This study investigates the theoretical link between these ICs and BBVC in SME architectural firms in the emerging markets, through a case study of Nigeria).

With increasing competitiveness in the AEC industry, maximising BIM business value creation has been regarded as a priority. However, the shift to its adoption and implementation in the emerging markets has brought distortion in both business processes and environments for firms in general and SME architectural firms in particular. Nevertheless, the larger firms with readily available resources could more easily invest in developing a viable business model. However, SME architectural firms are confronted with two paradoxical issues, namely trying to survive within a competitive environment by investing in BIM adoption amidst limited resources, but by doing so becomes more vulnerable to distortion in their established business processes.

This experience strongly reinforces the importance of exploring the IC potential of SME architectural firms to enhance their BBVC. Even if their individual abilities to mobilise resources for effective BIM implementation are relatively small, the strategic decisions regarding their orientation towards IC elements are under their control, and can be major catalysts for BIM success (Kim & Kumar, 2009) . Moreover, as most SME architectural firms cannot assume the financial risk of conducting a full-scale BIM implementation process, the importance of identifying and prioritising the factors that are most critical to the success of each level become even more necessary (Costa & Ramos, 2015). For this study, the BIM process in SME architectural firms was explained by the theories of IC and as a knowledge-based innovation that occurs with the development of HC, SC, RC through KC to form BBVC. In order for the firm to ensure this development to maximise its BBVC, there is a need for the proper identification and management of the various aspects that make up these capitals.

The study was designed in three stages, namely: empirical enquiry, analysis, and synthesis. The empirical enquiry comprised theory formulation and fieldwork data collection. The theory formulation was achieved through proposing an evaluation framework using a systematic literature review. The evaluation framework constituted a set of independent variables comprising thirteen components categorised under the four ICs. Each component was defined by a set of indicators. The proposition was to determine the relationship between these (independent) variables and the dependent variable of the BBVC capabilities of SME architectural firms. The evaluation framework was used to collect data from the fieldwork. It involved a questionnaire survey and case study interviews within a sample of SME architectural firms in Nigeria. The survey involved administering questionnaires, using hand-delivery, to 350 firms within nine cities in Nigeria during September 2015, and yielded 228 completed questionnaires by the end of December 2015; the case study interviews were conducted concurrently.

The survey data enabled the evaluation of the framework using multiple regression analysis. Each component and its sets of indicators represented an independent model of regression in the analysis. The outcome provided the statistical evidence of the relationship between the two main variables. Also, it provided the Relative Weighting Value (RWV) for each indicator within the components and their effects on BBVC. Furthermore, the case study analysis was used to triangulate the data from the survey results and provide the RWV for the components and the fours IC. The case study involved six SME architectural firms that have some BIM capabilities and were drawn from the survey sample during the administration of the questionnaire. The firms were asked during the survey if they would be interested in participating in the case study interviews and 23 firms indicated interest. When given short additional questions on BIM capability in the survey, only six firms qualified and were contacted for the case study interview.

The case study analysis was carried out using two approaches: firstly, an exploratory study using a semi-structured interview based on the thirteen components of the Intellectual Capitals, helped to identify the different indicators employed by the firms during BBVC. The analysis of these data was conducted using NVIVO software. Secondly, the Eigenvector method was used to analyse a pairwise comparison judgement where each of the components discussed in the interview was compared and weighted in terms of their relative importance. The outcome helped to establish the survey data's reliability and validity as well as provide the relative weighting value of the thirteen components and the four IC aspects.

The findings from the above approaches enabled the synthesis of a strategic business model using the Analytical Hierarchy Process (AHP) concept. The model aimed to enable practitioners to manage, prioritise and optimise their IC through the identification and evaluation of a focus area of development. The model was further validated practically through a focus group study with experts from the industry, on the three criteria of implementability, usefulness and generality. The feedback was used to adjust the model as appropriate and describe its practical implication.

Furthermore, the development of BBVC through the management of IC has further underpinned the knowledge-based orientation of the BIM adoption process. Thus, firms that appropriately understand how to employ their resources to develop their intellectual motivations, capabilities, network resources and knowledge management are bound to record better success in BIM processes. Moreover, when these different IC management aspects are deployed in order of priority, they encourage a firm to not only record its successes in the implementation but also to economise and manage their resources efficiently. For example, investing heavily in HC development with even a few of the other capitals can develop a firms' ability to form an efficient BBVC, at least at the firm level (Loner BIM). Meanwhile investing appropriately in RC and SC can expand the business value creation at the inter-firm level. The development of HC is the most essential part of IC and to BBVC; it is formed through the motivation and capability of the firm's IT manager, top manager and employees. However, by integrating the strength of the HCs equally with the support and capability of the SC and with the motivation and network resources resulting from the RC through proper knowledge resource management, firms can achieve their maximum BBVC.

7.3 ATTAINMENT OF OBJECTIVES:

This section presents how the analysis outcomes enabled the attainment of the study objectives;

Objective 1: To identify the various elements that form the development of the Intellectual Capital of SME architectural firms and their effect on BBVC.

Through a systematic literature review, the study began with the identification of thirteen components under the four aspects (Human, Relationship, Structure and Knowledge Capitals) of IC, which were understood to be relevant in affecting BBVC. The HC aspect comprises three of these components, which are: the motivation and capability of the IT manager, top manager and employees. The RC aspect comprises four components, which are the motivation and network resource resulting from internal, external and environmental relationships, and from image and reputation. The SC aspect comprises three components, which are: the capability and support of the firm's system structure, the infrastructural facilities, and the process schemes employed by the firm. The KC aspect comprises three components, which are the: knowledge exploration, knowledge exploitation and knowledge retention capacities. Through the literature review, these components were further divided into a set of indicators to form the unit elements of the IC. These identifications enabled the development of an evaluation framework for BBVC through the IC in SME architectural firms. Figure 31 illustrates this breakdown of the various capitals, indicators and components.

The evaluation framework formed the basis for collecting the fieldwork data through a survey study to establish the statistical effect of the elements and hierarchy on the Intellectual Capitals of SME architectural firms and their BBVC. The findings indicated that all thirteen components identified through the literature review significantly affect the capability of BBVC. However, not all the component indicators were significantly effective in the process.

Nonetheless, the findings provide the Relative Weighting Value for each indicator within the sets that make up each of the thirteen components. The outcome from this objective provided the basis for the development of the study's SBM model.

Objective 2: To examine the process of Intellectual Capital development by SME architectural firms with BIM capabilities through BBVC.

This objective was achieved through analysing a case study of six architectural firms in Nigeria with significant BIM capabilities. It involved semi-structured interviews on the thirteen components identified through the literature review, with the aim of identifying the different techniques and strategies they employ in the development of the Intellectual Capitals for BBVC. Similar to the assertion of the survey result, the firms employ several techniques, which were identified as indicators, to form each of the thirteen components. The consolidated analysis of the six firms demonstrates that the indicators employed by these firms also include all the indicators noted through the survey, as well as some that were acknowledged only within the literature review. However, the strength of this method lies in the fact that some new critical indicators were identified under certain Intellectual Capital components, which were neither identified through the literature review nor the survey results. Thus, such indicators can be considered for further empirical study since they cannot currently be generalised on the current evidence. Figure 33 illustrates these findings through the NVIVO TreeMap hierarchy chart.

Objective 3: To identify the extent of the influence of the various elements and hierarchy of the Intellectual Capitals on BBVC.

The findings for this objective are the identification of the RWV within the different component hierarchies, and the four basic IC elements. This was achieved through the case study analysis, through using a pairwise comparison method where each of the components under their respective aspects was compared for weighting. This method was appropriate because the firms applied their in-depth knowledge of these components during the interviews, which allowed them to offer an informed judgement. The analysis, which was conducted through the normalised principal Eigenvector, indicates the following:

Objective 4: To use the data to develop a Strategic Business Model (SBM) for the effective and efficient deployment of IC for BBVC in SME architectural firms in Nigeria.

This objective was achieved through modelling the results using AHP. The process involved the integration of all the elements and the IC hierarchy to form the management of critical elements using priority and optimisation. The hierarchy was a structured means of modelling the relative weight of the different elements of the IC identified through the analysis and consisted of four levels. The first level was the organisational goal, which is BBVC. The second level comprised the four basic IC aspects, and the relative weight values derived from the result of the pairwise comparison of the case study in objective three. The third level comprised the thirteen components under the four IC aspects, and their relative weight values derived from the pairwise comparison of the case study in objective three. The fourth level comprised the various indicators that defined the components, an alternative in managing the BBVC, and their relative weight values were from the multiple regression analysis of the survey result. This was reinforced by the exploratory method of the case study in Objectives 1 and 2.

The hierarchy was used to develop the Strategic Business Model and showed an area of focus in the development of the IC elements for BBVC. The business model provided a tool that described a clear focus area of priority for optimising BBVC, and a guide for managers to evaluate and manage their IC. The model used three focus areas, which were the core, general and potential focus areas. Each area constituted a guide on which part of the IC should be developed before others, amidst limited resources. This model was validated using a focus group interview with experts from the industry, based on the three criteria of implement-ability, usefulness and generality. The outcome was that the model was timely and easy to understand. The experts affirmed that prioritising intangible elements and identifying critical improvement areas can be key to mobilise IC management in efficiently creating BBVC. The experts also affirmed its applicability to the wider industry and the context in general. **Error! Reference source not found.** illustrates the model for the study.

Objective 5: To validate the SBM using the criteria of implementability, usefulness and generality.

This was achieved through a focus group study method, after the development and the modelling of the SBM, the study prepared a session with selected experts from the industry where data was collected to discuss the validity of the SBM. In line with other similar studies conducted, the study adopted three criteria in which the validation was performed; these are the Implementability, Generality and the Usefulness. The experts were left to discuss on the SBM based on these three criteria. The analysis of the discussion was used to strengthen the model. Findings are presented in the previous chapter.

7.4 CONTRIBUTION TO KNOWLEDGE

7.4.1 ACADEMIC BASED CONTRIBUTION

The research provides empirical evidence linking BBVC in SME architectural firms and the theory of IC development, which, despite its potential, has not been explored in previous studies. Through this study, the BIM adoption process has been recognised as a knowledge-based innovation, which occurs with the development of HC, SC, RC through KC to form BBVC. The study has provided with a theoretical insight into the context of the Nigerian AEC industry and the current state of BIM adoption processes.

The empirical identification of the various elements of IC provides a theoretical composition that constitutes the development of the BIM adoption capability by SME architectural firms. The examination of the firms that have relative BIM capabilities has provided an understanding of the different settings, techniques and strategies that firms in the emerging markets employ to achieve BIM capability, and this establishes a foundation for developing a holistic framework for further research in other contexts. The development of the strategic business model through the AHP has explored the possibility of integrating multiple regression results with the result of a pairwise comparison in modelling a priority model. Furthermore, the study has contributed to the debate on which approach can reconcile the cultural problems in a successful BIM adoption in the AEC industry.

The methodology in which this study was conducted is an intellectual merit of this study. Although, the study was carried out based on the data from the Nigerian context, the methodology can be applicable to different contexts of emerging markets. Thus, if a similar study can be undertaken with data from a given context of emerging market, the outcome and practical relevance can be as promising as this study.

Another important contribution of this study is its systematic identification of the various compositions of the four element of the IC through a literature review which is subsequently confirmed by the empirical data from the survey and the case study. Such an identification can be applicable to similar contexts of the emerging markets.

7.4.2 PRACTICE BASED CONTRIBUTION

The study developed a strategic business model for the BIM Business Value Creation. This model is expected to impact the AEC industry through the following dimensions. The identification of the different levels of hierarchy in the model has provided a baseline for acknowledging the importance of IC within SME architectural firms. The full potential of IC and its impact on innovation dynamics is realised when knowledge resources are efficiently identified through easy-to-use models and frameworks. The model is illustrated in **Error! Reference source not found.**.

- The model can help SME architectural firms understand where and when to invest their limited resources and activities appropriately to achieve efficient IC management for BBVC. Hence, it can help the firm to structure and prioritise critical IC elements that are suitable for their particular reality.
- The model can be utilised by SME architectural firms to identify their areas of weakness and strength through their existing capitals; hence it can guide them to improve their BIM adoption process.
- The model can help SME architectural firms and decision-makers to formulate viable guidelines for BIM adoption in the larger industry.
- The model can help SME architectural firms transform their IC identification and prioritisation into an efficient innovation management system.
- The model is a direct pathway to developing a holistic strategic framework for BIM adoption in the Nigerian AEC industry and similar emerging markets.

7.5 LIMITATIONS

This section outlines the limitations of this study. Firstly, the study of IC concerning the BIM process is still relatively new and, even though the study has established validity and reliability through incorporating multiple research methods, the qualitative approach (through the case study) has provided an interesting insight into several indicators that are neither identified through the literature nor the survey result. Investigations into these new explorations could be explored through further empirical study.

Secondly, as BIM adoption is a process involving a large number of stakeholders within the industry, this model has a limitation as it dealt with data from only the architectural firm's perspective, which is also firm-specific. Therefore, to extend it to other disciplines, the variables in this model must be regarded as a starting point, which can (and should) be subject to adaptations depending on the reality of the context.

Thirdly, the data was collected from a nine states within Nigeria as a representation of the AEC markets in the country, this facilitated data collection and controlling diversity but also limited generalisability of the findings.

7.6 FUTURE RESEARCH

The study is a stepping stone in relating BIM with the concept of Intellectual Capital development. Although the study has succeeded in context framing of the concept within the BIM field, there are issues which the study could not cover due to time and resource constraints of a PhD study. These are as follows:

1. A further study is required to employ additional qualitative approach to investigate and explore the various techniques the firms deploy their intellectual capital as opposed this study which uses largely the quantitative approach. This will allow for wider identification of the informal techniques employed by the SME architectural firms that is subjective to various contexts and constraints.
2. A broader scope for data collection is required to involve other major stakeholders in the construction industry, because studies related to Intellectual Capital development are best achieved when the data is diverse and representative of every stakeholder involved.
3. There is a need to establish empirically the effect and the manners at which the various indicators identified through the case study analysis only were developed in the context of the BBVC. This will allow the understanding of the various context and constraints that makes it differ from the literature earlier investigated in the study.

REFERENCES

Abimbola, T. & Kocak, A. (2007) Brand, organization identity and reputation: SMEs as expressive organizations. *Qualitative Market Research: An International Journal*, 10(4), 416-430.

Abubakar, M. (2012) *An Assessment Of Readiness Of The Nigerian Building Design Firms To Adopt Building Information Modelling (BIM) Technologies* Ahmadu Bello University, Zaria.

Abubakar, M., Ibrahim, Y., Kado, D. & Bala, K. (2014) Contractors' Perception of the Factors Affecting Building Information Modelling (BIM) Adoption in the Nigerian Construction Industry, *Computing in Civil and Building Engineering (2014)*, 167-178.

Adler, P. S. & Kwon, S.W. (2002) Social capital: Prospects for a new concept. *Academy of management review*, 27(1), 17-40.

Alcaniz, L., Gomez-Bezares, F. & Roslender, R. (2011) Theoretical perspectives on intellectual capital: A backward look and a proposal for going forward, *Accounting Forum*. Elsevier.

Amabile, T. M., Conti, R., Coon, H., Lazenby, J. & Herron, M. (1996) Assessing the work environment for creativity. *Academy of Management Journal*, 39(5), 1154-1184.

Andersson, S & Tell, J. 2009. The manager's influence on small firm growth. In Hörte, S. Å. (ed) *Research on Technology, Innovation and Marketing Management* 2007-2008, Halmstad University, Halmstad, pp. 1-14.

Andrew, D. P., Pedersen, P. M. & McEvoy, C. D. (2011) Research methods and design in sport management. Champaign, IL: Human Kinetics. Human Kinetics.

Andries, P. & Czarnitzki, D. (2014) Small firm innovation performance and employee involvement. *Small Business Economics*, 43(1), 21-38.

Apulu, I. (2012) Developing a framework for successful adoption and effective utilisation of ICT by SME in developing countries: a case study of Nigeria. PhD Thesis, University of Wolverhampton, UK.

Aramburu, N., Sáenz, J. & Blanco, C. (2013) Structural capital, innovation capability, and company performance in technology-based colombian firms, *Proceedings of the International Conference on Intellectual Capital, Knowledge Management & Organizational Learning*. April, pp. 20-29

Aranda-Mena, G., Crawford, J., Chevez, A. & Froese, T. (2009) Building information modelling demystified: does it make business sense to adopt BIM? *International Journal of managing projects in business*, 2(3), 419-434.

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C. & O'Reilly, K. (2011a) BIM adoption and implementation for architectural practices. *Structural Survey*, 29(1), 7-25.

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C. & O'reilly, K. (2011b) Technology adoption in the BIM implementation for lean architectural practice. *Automation in Construction*, 20(2), 189-195.

ARCON (2014) *Register of registered firms with Architect registration Council of Nigeria (ARCON).* Architect registration Council of Nigeria (ARCON)

Argote, L. (2012) Organizational learning: Creating, retaining and transferring knowledge *Springer Science & Business Media*.

Argote, L., McEvily, B. & Reagans, R. (2003) Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management Science*, 49(4), 571-582.

Arif, M., Egbu, C., Alom, O. & Khalfan, M. M. (2009) Measuring knowledge retention: a case study of a construction consultancy in the UAE. *Engineering, Construction and Architectural Management*, 16(1), 92-108.

Azzouz, A., & Hill, P. (2017). Hunting for perfection: How Arup measures BIM maturity on projects worldwide. Construction Research and Innovation, 8(2), 49-54.

Baldwin, J. R. & Johnson, J. (1996) Business strategies in more- and less-innovative firms in Canada. *Research Policy*, 25(5), 785-804.

Barber, E. & Manger, G. (1997) Improving management's valuations of human capital in small firms. *Journal of Management Development*, 16(7), 457-465.

Barlish, K. & Sullivan, K. (2012) How to measure the benefits of BIM—A case study approach. *Automation in Construction*, 24, 149-159.

Becerik-Gerber, B. & Rice, S. (2010) The perceived value of building information modeling in the US building industry. *Journal of Information Technology in Construction (ITcon)*, 15(15), 185-201.

Becker, G. S. (1994) Human capital revisited, *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (3rd Edition)* The University of Chicago Press, 15-28.

Becker, G. S. (2009) *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education* University of Chicago Press.

Bekkers, V. (2013) 17. E-government and innovation: the socio-political shaping of ICT as a source of innovation. *Handbook of Innovation in Public Services*, DOI: http://dx.doi.org/10.4337/9781849809757.00028. Pages: 253–268.

Bell, J., Crick, D. & Young, S. (2004) Small firm internationalization and business strategy an exploratory study of 'knowledge-intensive'and 'traditional'manufacturing firms in the UK. *International Small Business Journal*, 22(1), 23-56.

Bellamy, C. & Taylor, J. A. (1998) *Governing in the information age . Open university press, Buckingham, 1998, 196 p., ISBN 0-335-19450-8.*

Belsky, M., Sacks, R. & Brilakis, I. (2016) Semantic enrichment for building information modeling. *Computer‐Aided Civil and Infrastructure Engineering*, 31(4), 261-274.

Bergh, D. D., Ketchen, D. J., Boyd, B. K. & Bergh, J. (2010) New frontiers of the reputation—Performance relationship: Insights from multiple theories. *Journal of Management*, 36(3), 620-632.

Bernstein, P. G. & Pittman, J. H. (2004) Barriers to the adoption of building information modeling in the building industry. *Autodesk Building Solutions*.

Bew, M. & Richards, M. (2008) BIM maturity model, *Construct IT Autumn 2008 Members' Meeting. Brighton, UK*.

Bin Zakaria, Z., Mohamed Ali, N., Tarmizi Haron, A., Marshall-Ponting, A. & Abd Hamid, Z. (2013) Exploring the adoption of Building Information Modelling (BIM) in the Malaysian construction industry: A qualitative approach. *International Journal of Research in Engineering and Technology*, 2(8), 384-395.

Binder, M. & Coad, A. (2013) Life satisfaction and self-employment: a matching approach. *Small Business Economics*, 40(4), 1009-1033.

Bogner, W. C. & Bansal, P. (2007) Knowledge Management as the Basis of Sustained High Performance. *Journal of Management Studies*, 44(1), 165-188.

Bourdage, J. S., Wiltshire, J. & Lee, K. (2015) Personality and workplace impression management: Correlates and implications. *Journal of Applied Psychology*, 100(2), 537-546.

Bourgeois, L. J. (1980) Strategy and Environment: A Conceptual Integration. *Academy of Management Review*, 5(1), 25-39.

Brandon, P. S. & Lu, S.L. (2009) *Clients Driving Innovation* John Wiley & Sons.

Brannen, J. (2005) Mixing methods: The entry of qualitative and quantitative approaches into the research process. *International Journal of Social Research Methodology*, 8(3), 173-184.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3, 77–101.

Brown, L. & Osborne, S. P. (2013) Risk and innovation: Towards a framework for risk governance in public services. *Public Management Review*, 15(2), 186-208.

Bryman, A. (2015) *Social research methods* Oxford University Press.

BuildingSMARTalliance (2015) *What is a BIM?* . (2015. Available online: http://www.

buildingsmartalliance.org/index.php/nbims [Accessed 2015].

Burt, R. S. (2001) Closure as social capital. *Social Capital: Theory and Research*, 31-56.

Cabrita, M. d. R., Vaz, J. L. D. & Bontis, N. (2007) Modelling the creation of value from intellectual capital: a Portuguese banking perspective. *International Journal of Knowledge and Learning*, 3(2/3), 266.

Cadwallader, S., Jarvis, C. B., Bitner, M. J. & Ostrom, A. L. (2009) Frontline employee motivation to participate in service innovation implementation. *Journal of the Academy of Marketing Science*, 38(2), 251-251.

Caywood, C. L. (1997) The handbook of strategic public relations and integrated communications. New York : McGraw-Hill services, ISBN-10: 0786311312.

Chen, J., Zhu, Z. & Yuan Xie, H. (2004) Measuring intellectual capital: a new model and empirical study. *Journal of Intellectual Capital*, 5(1), 195-212.

Chen, C. C. (2011). Quantitative methodology: Appropriate use in research for blind baseball ergonomics and safety design. The Journal of Human Resource and Adult Learning, 7(1), 1.

Chesbrough, H. (2013) *Open business models: How to thrive in the new innovation landscape* Harvard Business Press.

Chimhanzi, J. & Morgan, R. E. (2005) Explanations from the marketing/human resources dyad for marketing strategy implementation effectiveness in service firms. *Journal of Business Research*, 58(6), 787-796.

Claudio, M. (2008) CIFE Horse Shoe: Center for Integrated Facility Engineering, University of Stanford, USA

Clegg, C., Unsworth, K., Epitropaki, O. & Parker, G. (2002) Implicating trust in the innovation process. *Journal of Occupational and Organizational Psychology*, 75(4), 409-422.

Clough, P. & Nutbrown, C. (2012) *A student's guide to methodology* Sage. SAGE Journal of Early Childhood Research, ISBN: 9781446208625.

Codinhoto, R., Kiviniemi, A., Kemmer, S. & da Rocha, C. G. (2013) BIM-FM implementation: an exploratory invesigation. *International Journal of 3-D Information Modeling (IJ3DIM)*, 2(2), 1-15.

Cohen, S. & Kaimenakis, N. (2007) Intellectual capital and corporate performance in knowledge-intensive SME s. *The Learning Organization*, 14(3), 241-262.

Collis, J. & Hussey, R. (2013) *Business research: A practical guide for undergraduate and postgraduate students* Palgrave Macmillan.

Construction, M. H. (2014) The Business Value of BIM For Construction in Major Global Markets: how contractors around the world are driving innovation with building information modeling. *Smart Market Report*. publishded by McGraw Hill Construction.

Cooper, D. & Schindler, P. (1998) Business methods. Mc Graw Hill International Edition.

Costa, R. V., Fernández-Jardon Fernández, C. & Figueroa Dorrego, P. (2014) Critical elements for product innovation at Portuguese innovative SMEs: an intellectual capital perspective. *Knowledge Management Research & Practice*, 12(3), 322-338.

Costa, R. V. & Ramos, A. P. (2015) Designing an AHP methodology to prioritize critical elements for product innovation: an intellectual capital perspective. *Int. Journal of Business Science and Applied Management*, 10(1).

Curley, M. G. (2004) *Managing Information Technology for Business Value: Practical Strategies for IT and Business Managers (IT Best Practices series)* Intel Press.

Damanpour, F. & Gopalakrishnan, S. (2001) The dynamics of the adoption of product and process innovations in organizations. *Journal of Management Studies*, 38(1), 45-65.

De Vaus, D. A. & de Vaus, D. (2001) *Research design in social research, published by* SAGE.

Dictionary, T. A. H. (2011) *The American Heritage Dictionary of the English Language* Houghton Mifflin Harcourt.

Dorrego, P. F., Costa, R. V. & Fernández, C. F.J. (2013) Product innovation and relational capital: Evidence from Portugal. *Electronic Journal of Knowledge Management*, 11(4), 295-308.

Dudovskiy, J. (2016) The Ultimate Guide to Writing a Dissertation in Business Studies: A step by-step assistance. *Research-methodology. retrived 27th Nov, 2017*

Eastman, C. M., Eastman, C., Teicholz, P. & Sacks, R. (2011) *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors* John Wiley & Sons.

Edvinsson, L. & Malone, M. S. (1997) Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower. Front Cover. Leif Edvinsson. Harper Collins, Mar 6, 1997

Egbu, C. & Botterill, K. (2001) Knowledge management and intellectual capital: benefits for project based industries, *Proceedings of the COBRA Conference, London, RICS Foundation*.

Egbu, C. O. (2004) Managing knowledge and intellectual capital for improved organizational innovations in the construction industry: an examination of critical success factors. *Engineering, Construction and Architectural Management*, 11(5), 301-315.

Eisenegger, M. & Imhof, K. (2008) The True, the Good and the Beautiful: Reputation Management in the Media Society, in Zerfass, A., van Ruler, B. & Sriramesh, K. (eds), *Public Relations Research: European and International Perspectives and Innovations*. Wiesbaden: VS Verlag für Sozialwissenschaften, 125-146.

Elsetouhi, A., Elbeltagi, I. & Haddoud, M. Y. (2015) Intellectual capital and innovations: is organisational capital a missing link in the service sector? *International Journal of Innovation Management*, 19(02), 1550020.

Enz, C. A. (2012) Strategies for the Implementation of Service Innovations. *Cornell Hospitality Quarterly*, 53(3), 187-195.

Erik Sveiby, K. (1997) The intangible assets monitor. *Journal of Human Resource Costing & Accounting*, 2(1), 73-97.

Fellows, R. F. & Liu, A. M. (2015) *Research methods for construction* John Wiley & Sons.

Forsythe, P. (2014) The Case for BIM Uptake among Small Construction Contracting Businesses, *ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction*. Vilnius Gediminas Technical University, Department of Construction Economics & Property.

Frees, E. W. (1996) *Data analysis using regression models: the business perspective*. Published. Englewood Cliffs, NJ : Prentice Hall, 1996

Friedman, V. J., Lipshitz, R. & Overmeer, W. (2001) Creating conditions for organizational learning. *Handbook of organizational learning and knowledge*, 757-774.

Fu, Q. (2004) *Trust, social capital, and organizational effectiveness publisdhed by* Virginia Polytechnic Institute and State University.

Gallaher, M. P., O'Connor, A. C., Dettbarn, J. J. L. & Gilday, L. T. (2004) *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry*. National Institute of Standards and Technology (NIST).

Ganah, A. & John, G. A. (2014) Achieving Level 2 BIM by 2016 in the UK, *Computing in Civil and Building Engineering ASCE*, 143-150.

García-Morales, V. J., Lloréns-Montes, F. J. & Verdú-Jover, A. J. (2007) Influence of personal mastery on organizational performance through organizational learning and innovation in large firms and SMEs. *Technovation*, 27(9), 547-568.

Garud, R. & Nayyar, P. R. (1994) Transformative capacity: Continual structuring by intertemporal technology transfer. *Strategic Management Journal*, 15(5), 365-385.

Gligorijevic, B. & Leong, B. (2011) Trust, Reputation and the Small Firm: Building Online Brand Reputation for SMEs, Proceedings of the Fifth International Conference on. Weblogs and Social Media (ICWSM), Barcelona, Catalonia, Spain

Goepel, K. D. (2013a) Implementing the analytic hierarchy process as a standard method for multi-criteria decision making in corporate enterprises–a new AHP excel template with multiple inputs, *Proceedings of the International Symposium on the Analytic HierarchyPprocess*.

Goepel, K. D. (2013b) Implementing the analytic hierarchy process as a standard method for multi-criteria decision making in corporate enterprises–a new AHP excel template with multiple inputs, *Proceedings of the International Symposium on the Analytic Hierarchy Process*.

Golafshani, N. (2003) Understanding reliability and validity in qualitative research. *The Qualitative Report*, 8(4), 597-606.

Gottschalk, P. (2009) Maturity levels for interoperability in digital government. *Government Information Quarterly*, 26(1), 75-81.

Grabner-Kräuter, S. & Kaluscha, E. A. (2008) 1. Consumer trust in electronic commerce: conceptualization and classification of trust building measures. *Trust and New Technologies: Marketing and Management on the Internet and Mobile Media*, Cheltenham, UK and. Lyme, US: Edward Elgar.

Grant, C. & Osanloo, A. (2014) Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house". *Administrative Issues Journal*, 4(2), 4.

Grant, R. M. & Baden-Fuller, C. (2004) A Knowledge Accessing Theory of Strategic Alliances. *Journal of Management Studies*, 41(1), 61-84.

Guler, I., Guillén, M. F. & Macpherson, J. M. (2002) Global competition, institutions, and the diffusion of organizational practices: The international spread of ISO 9000 quality certificates. *Administrative Science Quarterly*, 47(2), 207-232.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. & Tatham, R. L. (1998) *Multivariate data analysis*, Prentice Hall Upper Saddle River, NJ.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. & Tatham, R. L. (2006) Multivariate data analysis 6th Edition. *New Jersey: Pearson Education*.

Hammad, D., Rishi, A. & Yahaya, M. (2012) Mitigating construction project risk using Building Information Modelling (BIM), *Proceedings of 4th West Africa Built Environment Research (WABER) Conference in Abuja, Nigeria*.

Harty, J. (2012) The impact of digitalisation on the management role of architectural technology.PhD Thesis RGU, https://openair.rgu.ac.uk/handle/10059/742 retrieved 27th, Nov, 2017

Hayton, J. C. (2005) Competing in the new economy: the effect of intellectual capital on corporate entrepreneurship in high-technology new ventures. *R and D Management*, 35(2), 137-155.

Hildreth, P. M. & Kimble, C. (2004) *Knowledge networks: Innovation through communities of practice*. Publisher: IGI Global (July 1, 2003); Language: English; ISBN-10: 159140200X.

Ho, D., Newell, G. & Walker, A. (2005) The importance of property-specific attributes in assessing CBD office building quality. *Journal of Property Investment & Finance*, 23(5), 424-444.

Hoegl, M., Parboteeah, K. P. & Munson, C. L. (2003) Team-level antecedents of individuals' knowledge networks. *Decision Sciences*, 34(4), 741-770.

Holzer, D. (2015) *The BIM Manager's Handbook, Part 2: Change Management* John Wiley & Sons.

Hosseini, M. R., Banihashemi, S., Chileshe, N., Namzadi, M. O., Udaeja, C., Rameezdeen, R. & McCuen, T. (2016) BIM adoption within Australian Small and Medium-sized Enterprises (SMEs): an innovation diffusion model. *Construction Economics and Building*, 16(3), 71-86.

Hurt, H. T., Joseph, K. & Cook, C. D. (1977) Scales for the measurement of innovativeness. *Human Communication Research*, 4(1), 58-65.

Hussey, J. & Hussey, R. (1997) Business research. *Hampshire: Palgrave*.

Hutchinson, A. & Finnemore, M. (1999) Standardized process improvement for construction enterprises. *Total Quality Management*, 10(4-5), 576-583.

Ibrahim, Y. m. & Abullahi, M. (2016) Introduction to Building Information Modelling, *A 3 – Day Workshop/ Annual General Meeting Of The Nigerian Institute Of Quantity Surveyors*. Port-Harcourt.

Ichijo, K. (2007) Enabling knowledge-based competence of a corporation. *Knowledge Creation and Management: New Challenges for Managers*, 83-96.

Jansen, J. J. P., Van Den Bosch, F. A. J. & Volberda, H. W. (2006) Exploratory Innovation, Exploitative Innovation, and Performance: Effects of Organizational Antecedents and Environmental Moderators. *Management Science*, 52(11), 1661-1674.

Jaradat, S., Whyte, J. & Luck, R. (2013) Professionalism in digitally mediated project work. *Building Research & Information*, 41(1), 51-59.

Jo, S. & Shim, S. W. (2005) Paradigm shift of employee communication: The effect of management communication on trusting relationships. *Public Relations Review*, 31(2), 277-280.

Jongeling, R. (2008) *BIM istället för 2D-CAD i byggprojekt: en jämförelse mellan dagens byggprocesser baserade på 2D-CAD och tillämpningar av BIM* Luleå tekniska universitet, Sweden. [Research Report: BIM instead of 2D CAD in construction projects - a comparison between today's construction processes based on 2D CAD and Applications of BIM] Kale, P. & Singh, H. (2007) Building firm capabilities through learning: the role of the alliance learning process in alliance capability and firm-level alliance success. *Strategic Management Journal*, 28(10), 981-1000.

Kalla, H. K. (2005) Integrated internal communications: a multidisciplinary perspective. *Corporate Communications: An International Journal*, 10(4), 302-314.

Kang, S.C. & Snell, S. A. (2009) Intellectual Capital Architectures and Ambidextrous Learning: A Framework for Human Resource Management. *Journal of Management Studies*, 46(1), 65-92.

Kappler, E. (1980) Book Reviews : Chris Argyris and Donald A. Schon: Organizational Learning. A Theory of Action Perspective 1978, Reading, Mass.: Addison-Wesley. *Organization Studies*, 1(3), 292-293.

Karchegani, M. R., Sofian, S. & Amin, S. M. (2013) The relationship between intellectual capital and innovation: a review. *International Journal of Business and Management Studies*, 2(1), 561-581.

Kassem, M., Succar, B. & Dawood, N. (2013) A proposed approach to comparing the BIM maturity of countries. Proceedings of the CIB W78 2013: 30th International Conference – Beijing, China, 9-12 October

Kassem, M., Succar, B. & Dawood, N. (2015) Building information modeling: analyzing noteworthy publications of eight countries using a knowledge content taxonomy: American Society of Civil Engineers. pp. 329-371

Kennedy, R., Xiang, X., Madey, G. & Cosimano, T. (2005) Verification and validation of scientific and economic models, Proc. Agent, Chicago, pp 177–192.

Khilji, S. E., Mroczkowski, T. & Bernstein, B. (2006) From invention to innovation: Toward developing an integrated innovation model for biotech firms. *Journal of Product Innovation Management*, 23(6), 528-540.

Kim, D.-Y. & Kumar, V. (2009) A framework for prioritization of intellectual capital indicators in R&D. *Journal of Intellectual Capital*, 10(2), 277-293.

Kiviniemi, A. (2005) *Product Model Based Requirements Management* Ph. D. Thesis, Stanford Univ.

Kiviniemi, A. (2006) Clients driving innovation: moving ideas into practice. *Cooperative Research Centre (CRC) for Construction Innovation*

Kiviniemi, A. (2011) The effects of Integrated BIM in processes and business models. *Distributed Intelligence in design*, page 125-135.

Knight, A. & Ruddock, L. (2009) *Advanced research methods in the built environment* John Wiley & Sons.

Kocatürk, T. (2006) Modelling collaborative knowledge in digital free-form design. PhD thesis, Tudelft retrived https://repository.tudelft.nl/islandora/object/uuid:2dcae3a7-0811-450b-9a3d-81f7674c8458?collection=research on 27th Nov, 2017

Kohli, R. & Grover, V. (2008) Business value of IT: An essay on expanding research directions to keep up with the times. *Journal of the Association for Information Systems*, 9(1), 23.

Kori, S. A. (2013) *Toward Adoption of Building Information Modelling in the Nigeria AEC industry*MSc. School of Built Enviroment, University of Salford, UK.

Kori, S. A. & Kiviniemi, A. (2015) Toward adoption of bim in the nigerian aec industry; context framing, data collecting and paradigm for interpretation. http://bimforum.org/wp-content/uploads/2015/05/BIMAS2015Proceedings.compressed.pdf.

Kwak, Y. H. & Ibbs, C. W. (2002) Project management process maturity (PM) 2 model. *Journal of Management in Engineering*, 18(3), 150-155.

Laforet, S. (2010) Chapter 6 Organizational innovation and outcomes in SMEs, *Organizational Culture, Business-to-Business Relationships, and Interfirm Networks* Emerald Group Publishing Limited, 341-362.

Landry, R., Amara, N. & Lamari, M. (2002) Does social capital determine innovation? To what extent? *Technological Forecasting and Social Change*, 69(7), 681-701.

Lane, P. J., Koka, B. R. & Pathak, S. (2006) The Reification Of Absorptive Capacity: A Critical Review And Rejuvenation Of The Construct. *Academy of Management Review*, 31(4), 833-863.

Laosirihongthong, T., Prajogo, D. I. & Adebanjo, D. (2014) The relationships between firm's strategy, resources and innovation performance: resources-based view perspective. *Production Planning & Control*, 25(15), 1231-1246.

Laperche, B. & Liu, Z. (2013) SMEs and knowledge-capital formation in innovation networks: a review of literature. *Journal of Innovation and Entrepreneurship*, 2(1), 21.

Lee, S., Yu, J. & Jeong, D. (2013) BIM acceptance model in construction organizations. *Journal of Management in Engineering*, 31(3), 04014048.

Leeuwis, A. B. (2012) BIM at small architectural firms.MSc Thesis, Delft University of Technology.

Lehtinen, T. (2011) Boundaries Matter–The Pros and Cons of Vertical Integration in BIM Implementation, *IFIP International Conference on Advances in Production Management Systems*. Springer.

Leonard-Barton, D. (1992) Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal*, 13(S1), 111-125.

Lichtenstein, B. M. B. & Brush, C. G. (2001) How do "resource bundles" develop and change in new ventures? A dynamic model and longitudinal exploration. *Entrepreneurship: Theory and Practice*, 25(3), 37-37.

Lichtenthaler, U. & Lichtenthaler, E. (2009) A capability-based framework for open innovation: Complementing absorptive capacity. *Journal of Management Studies*, 46(8), 1315-1338.

Liu, D., Wang, S. & Wayne, S. J. (2014) Is Being a Good Learner Enough? An Examination of the Interplay Between Learning Goal Orientation and Impression Management Tactics on Creativity. *Personnel Psychology*, 68(1), 109-142.

Lockamy III, A. & McCormack, K. (2004) The development of a supply chain management process maturity model using the concepts of business process orientation. *Supply Chain Management: An International Journal*, 9(4), 272-278.

Longacre Jr, A. & Hussey, R. (1997) Two dimensional data encoding structure and symbology for use with optical readers. Google Patents.

Lorenzoni, G. & Lipparini, A. (1999) The leveraging of interfirm relationships as a distinctive organizational capability: a longitudinal study. *Strategic Management Journal*, 317-338.

Love, J. H., Roper, S. & Vahter, P. (2014) Learning from openness: The dynamics of breadth in external innovation linkages. *Strategic Management Journal*, 35(11), 1703-1716.

Lowendahl, B. (2000) The globalization of professional business service firms: fad or genuine source of competitive advantage? Routledge studies in international business and the world economy, 19, 142-162.

Lu, N. & Korman, T. (2010) Implementation of building information modeling (BIM) in modular construction: Benefits and challenges, *Construction Research Congress 2010: Innovation for Reshaping Construction Practice*.

Lu, S. L. & Sexton, M. (2006) Innovation in small construction knowledge-intensive professional service firms: a case study of an architectural practice. *Construction Management and Economics*, 24(12), 1269-1282.

Lu, S. L. & Sexton, M. (2009) *Innovation in Small Professional Practices in the Built Environment* Wiley.

Luoma-aho, V. (2007) Reputation formation of innovations. *Innovation Journalism*, 4(2), 1-11.

Majchrzak, A., Cooper, L. P. & Neece, O. E. (2004) Knowledge reuse for innovation. *Management Science*, 50(2), 174-188.

Malhotra, N., Smets, M. & Morris, T. (2016) Career Pathing and Innovation in Professional Service Firms. *The Academy of Management Perspectives*, 30(4), 369-383.

McGraw-Hill (2009) The Business Value Of BIM. Getting Building Information Modeling to the Bottom Line. *Bedford: McGraw Hill Construction*.

McGuirk, H., Lenihan, H. & Hart, M. (2015) Measuring the impact of innovative human capital on small firms' propensity to innovate. *Research Policy*, 44(4), 965-976.

Melton, H. L. & Hartline, M. D. (2010) Customer and Frontline Employee Influence on New Service Development Performance. *Journal of Service Research*, 13(4), 411-425.

Miles, M. B. & Huberman, A. M. (1994) *Qualitative data analysis: An expanded sourcebook Thousand Oaks, CA: Sage Publications.*

Miller, D. (2012) BIM from the point of view of a small practice. *BIM (Building Information Modelling)*. Available online: https://www.thenbs.com/knowledge/bim-from-the-point-of-view-of-a-small-practice [Accessed 2016].

Mincer, J. A. (1974) Schooling and earnings, *Schooling, Experience, and Earnings* NBER, 41-63.

Mingers, J. & Gill, A. (1997) *Multimethodology: theory and practice of combining management science methodologies* Wiley.

Mollaoglu, S., Syal, C. M. & CPC, C. (2015) Adoption of Building Information Modeling in Small Size Home-Building-Businesses. Phd thesis, Michigan State University.

Montalvo, C. (2006) What triggers change and innovation? *Technovation*, 26(3), 312-323.

Morris, S. S. & Snell, S. A. (2011) Intellectual capital configurations and organizational capability: An empirical examination of human resource subunits in the multinational enterprise. *Journal of International Business Studies*, 42(6), 805-827.

Nach, E. J. (2009) *Instructional use of research-based practices for students with autism spectrum disorder* ProQuest.

Nahapiet, J. & Ghoshal, S. (1998) Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review*, 23(2), 242-266.

Namvar, M., Fathian, M., Gholamin, M. R. & Akhavan, P. (2012) Exploring the Role of Human Capital on Firm's Structural Capital in Iranian E-Business Industry. 3rd International Conference on. Information and Financial Engineering, IPEDR vol. 12

NIBS. 2007. BIM Capability Maturity model, National Institute for Building Sciences (NIBS) Facility Information Council (FIC). Retrieved October 11, 2008, from www.buildingsmartalliance.org/client/assets/files/bsa/BIM_CMM_v1.9.xls accessed 27th Nov, 2017

Newton, P., Hampson, K. & Drogemuller, R. (2009) *Technology, Design and Process Innovation in the Built Environment* Taylor & Francis.

Ngah, R. & Ibrahim, A. R. (2011) The Influence of Intellectual Capital on Knowledge Sharing: Small and Medium Enterprises' Perspective. IBIMA Publishing Communications of the IBIMA DOI: 10.5171/2011.444770 .

Nonaka, I. (1994) A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, 5(1), 14-37.

Nonaka, I. & Takeuchi, H. (1996) The knowledge-creating company: How Japanese companies create the dynamics of innovation. *Long Range Planning*, 29(4), 592.

Nonaka, I. & Toyama, R. (2003) The knowledge-creating theory revisited: knowledge creation as a synthesizing process. *Knowledge Management Research & Practice*, 1(1), 2-10.

Nonaka, I., Toyama, R. & Hirata, T. (2008) *Managing flow: A process theory of the knowledge-based firm* Springer.

Nooteboom, B. (2006) Trust and innovation. *Germany: Dutch Ministry of Economics Affaires.* Edward Elgar Publishing.

Ogwueleka, A. C. (2015) Upgrading from the use of 2D CAD systems to BIM technologies in the construction industry: consequences and merits. *International Journal of Engineering Trends and Technology (IJETT)*, 28(8), 403-411.

Oh, H., Labianca, G., & Chung, M. H. (2006). A multilevel model of group social capital. Academy of management review, 31(3), 569-582.

Oladapo, A. A. (2006) The impact of ICT on professional practice in the Nigerian construction industry. *The Electronic Journal of Information Systems in Developing Countries*, 24(2), pp. 1-19, 2006

Oladapo, A. A. (2007) An investigation into the use of ICT in the Nigerian construction industry. *Journal of Information Technology in Construction (ITcon)*, 12(18), 261-277.

Oluwatayo, A. A. (2009) *A critical study of the practice characteristics of architectural firms in Nigeria* Covenant University.

Onwuegbuzie, A. J. & Leech, N. L. (2005) On Becoming a Pragmatic Study: The Importance of Combining Quantitative and Qualitative Research Methodologies. *International Journal of Social Research Methodology*, 8(5), 375-387.

Ou, Y.C. & Hsu, L.C. (2013) How Does Corporate Reputation Affect Innovative Performance? *International Business Research*, 6(12), 46.

Owen, R. L., Palmer, M. E., Dickinson, J. K., Tatum, C. B., Kazi, A. S., Amor, R. & Prins, M. (2009) CIB White Paper on IDDS Integrated Design & Delivery Solutions.

Oyediran, O. S. & Odusami, K. T. (2005) A study of computer usage by Nigerian quantity surveyors. *Journal of Information Technology in Construction (ITcon)*, 10(20), 291-303.

Podmetina, D. & Smirnova, M. (2013) R&D Cooperation with External Partners and Implementing Open Innovation. *Journal of Innovation Management*, 1(2), 103-124.

Poirier, E., Staub-French, S. & Forgues, D. (2015) Embedded contexts of innovation: BIM adoption and implementation for a specialty contracting SME. *Construction Innovation*, 15(1), 42-65.

Prajogo, D. I. (2006) The relationship between innovation and business performance—a comparative study between manufacturing and service firms. *Knowledge and Process Management*, 13(3), 218-225.

Rabey, G. (2000) Whither HR? Don't people matter anymore? *Industrial and Commercial Training*, 32(1), 19-23.

Racheva, Z., Daneva, M. & Sikkel, K. (2009) Value creation by agile projects: Methodology or mystery?, *International Conference on Product-Focused Software Process Improvement*. Springer.

Reed, K. K., Lubatkin, M. & Srinivasan, N. (2006) Proposing and testing an intellectual capital-based view of the firm. *Journal of Management Studies*, 43(4), 867-893.

Rindova, V. P., Williamson, I. O. & Petkova, A. P. (2010) Reputation as an intangible asset: Reflections on theory and methods in two empirical studies of business school reputations. *Journal of Management*, 36(3), 610-619.

Rispoli, L., & Leung, D. (2011). The Contribution of Small and Medium-sized Businesses to Gross Domestic Product: A Canada-United States Comparison (No. 2011070e). Statistics Canada, Analytical Studies Branch.

Roberts, P. W. & Dowling, G. R. (2002) Corporate reputation and sustained superior financial performance. *Strategic Management Journal*, 23(12), 1077-1093.

Romer, P. M. (1990) Human capital and growth: theory and evidence, *Carnegie-Rochester conference series on public policy*. Elsevier.

Roscoe, J. T. (1975) *Fundamental research statistics for the behavioral sciences [by] John T. Roscoe*New York, NY: Holt, Rinehart and Winston.

Rothenberg, S. & Zyglidopoulos, S. C. (2007) Determinants of environmental innovation adoption in the printing industry: the importance of task environment. *Business Strategy and the Environment*, 16(1), 39-49.

Saaty, T. L. (2008) Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, 1(1), 83-98.

Santos-Rodrigues, H., Dorrego, P. F. & Jardon, C. F. (2010) The Influence Of Human Capital On The Innovativeness Of Firms. *International Business & Economics Research Journal (IBER)*, 9(9).

Saunders, M. N. (2011) *Research methods for business students, 5/e* Pearson Education India.

Scarbrough, H. (2003) Knowledge management, HRM and the innovation process. *International Journal of Manpower*, 24(5), 501-516.

Scarbrough, H., Preston, J. & Swan, J. (1999) *Knowledge management: a literature review* Institute of Personnel and Development London.

Schaarschmidt, M. (2016) Frontline employees' participation in service innovation implementation: The role of perceived external reputation. *European Management Journal*, 34(5), 540-549.

Schryen, G. (2013) Revisiting IS business value research: what we already know, what we still need to know, and how we can get there. *European Journal of Information Systems*, 22(2), 139-169.

Sekaran, U. (2003) Research methods for business: A skill approach. *New Jersey: John Willey and Sons, Inc*.

Sexton, M. & Barrett, P. (2003) A literature synthesis of innovation in small construction firms: insights, ambiguities and questions. *Construction Management and Economics*, 21(6), 613-622.

Sexton, M. & Barrett, P. (2004) The role of technology transfer in innovation within small construction firms. *Engineering, Construction and Architectural Management*, 11(5), 342-348.

Shipton, H., Fay, D., West, M., Patterson, M. & Birdi, K. (2005) Managing People to Promote Innovation. *Creativity and Innovation Management*, 14(2), 118-128.

Simao, L. B., Rodrigues, R. G. & Madeira, M. J. (2016) External relationships in the organizational innovation. *RAI Revista de Administração e Inovação*, 13(3), 156-165.

Simpson, P. M., Siguaw, J. A. & Enz, C. A. (2006) Innovation orientation outcomes: The good and the bad. *Journal of Business Research*, 59(10), 1133-1141.

Sinclair, D. (2012) BIM overlay to the RIBA outline plan of work. *London, UK: RIBA*.

Smith, D. K. & Tardif, M. (2009) *Building information modeling: a strategic implementation guide for architects, engineers, constructors, and real estate asset managers* John Wiley & Sons.

Smith, K. G., Collins, C. J. & Clark, K. D. (2005) Existing knowledge, knowledge creation capability, and the rate of new product introduction in high-technology firms. *Academy of Management Journal*, 48(2), 346-357.

Snyder, H. W. & Pierce, J. B. (2002) Intellectual capital. *Annual review of information science and Technology*, 36(1), 467-500.

Statistics Solutions. (2013). Data analysis plan: Moderation Analysis [WWW Document]. Retrieved from http://www.statisticssolutions.com/academic-solutions/member-resources/member-profile/data-analysis-plan-templates/data-analysis-plan-moderation-analysis/ retrieved 27th Nov, 2017.

Somech, A. & Drach-Zahavy, A. (2013) Translating Team Creativity to Innovation Implementation. *Journal of Management*, 39(3), 684-708.

Stewart, T. A. (1997) Intellectual capital. The new wealth of nations. Doubleday, New York, NY.

Stuart, R. & Abetti, P. A. (1988) Field study of technical ventures-Part III: The impact of entrepreneurial and management experience on early performance. *Frontiers of Entrepreneurship Research*, page 177-193.

Su, Y.-S., Tsang, E. W. & Peng, M. W. (2009) How do internal capabilities and external partnerships affect innovativeness? *Asia Pacific Journal of Management*, 26(2), 309-331.

Subramaniam, M. & Youndt, M. A. (2005) The influence of intellectual capital on the types of innovative capabilities. *Academy of Management Journal*, 48(3), 450-463.

Succar, B. (2009) Building information modelling maturity matrix. *Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies, IGI Global*, 65-103. published by Information Science Reference, IGI Publishing, pp.65-103

Succar, B. & Kassem, M. (2015) Macro-BIM adoption: Conceptual structures. *Automation in Construction*, (57), 64-79.

Succar, B., Sher, W. & Williams, A. (2012) Measuring BIM performance: Five metrics. *Architectural Engineering and Design Management*, 8(2), 120-142.

Teixeira, A. A. & Tavares-Lehmann, A. T. (2014) Human capital intensity in technology-based firms located in Portugal: Does foreign ownership matter? *Research Policy*, 43(4), 737-748.

Tether, B. S. & Hipp, C. (2002) Knowledge intensive, technical and other services: patterns of competitiveness and innovation compared. *Technology Analysis & Strategic Management*, 14(2), 163-182.

Tether, B. S. & Tajar, A. (2008) Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. *Research Policy*, 37(6), 1079-1095.

Thornhill, S. (2006) Knowledge, innovation and firm performance in high- and low-technology regimes. *Journal of Business Venturing*, 21(5), 687-703.

Ticehurst, G. W. & Veal, A. J. (2000) *Business research methods: A managerial approach* Addison Wesley Longman.

Ting, H.-F., Wang, H.-B. & Wang, D.-S. (2012) The moderating role of environmental dynamism on the influence of innovation strategy and firm performance. *International Journal of Innovation, Management and Technology*, 3(5), 517.

Toner, P. (2011) Workforce skills and innovation: an overview of major themes in the literature. *OECD Education Working Papers*(55), 0_1.

Toole, T. M. (1998) Uncertainty and home builders' adoption of technological innovations. *Journal of Construction Engineering and Management*, 124(4), 323-332.

Trochim, William M.K. (2006, October 20). Research Methods Knowledge Base. Retrieved from http://www.socialresearchmethods.net/kb/scallik.php : 27th Nov, 2017.

Tsai, W. & Ghoshal, S. (1998) Social capital and value creation: The role of intrafirm networks. *Academy of Management Journal*, 41(4), 464-476.

Vaidyanathan, K. & Howell, G. (2007) Construction supply chain maturity model–conceptual framework, *Proceedings IGLC*.

Valenzuela, A. & Contreras, O. F. (2014) Trust and Innovation: Small and Medium Enterprises within Global Value Chains in Northern Mexico. *Journal of Small Business and Entrepreneurship Development*, Vol. 2, Issue 3 &4, p. 47-72.

Vass, S. (2014) A proposed BIM business value model, *30th Annual Association of Studys in Construction Management Conference, ARCOM 2014; Portsmouth; United Kingdom*.

Vass, S. (2015) *An Organizational Perspective on the Business Value of BIM*KTH Royal Institute of Technology.

Venugopal, M., Eastman, C. M., Sacks, R. & Teizer, J. (2012) Semantics of model views for information exchanges using the industry foundation class schema. *Advanced Engineering Informatics*, 26(2), 411-428.

Vroom, V. H. (1964) Work and motivation. 1964. *NY: John Wiley & Sons*, 45.

Wang, C. L. & Ahmed, P. K. (2004) The development and validation of the organisational innovativeness construct using confirmatory factor analysis. *European Journal of Innovation Management*, 7(4), 303-313.

Webb, E. J., Campbell, D. T., Schwartz, R. D. & Sechrest, L. (1966) *Unobtrusive measures: Nonreactive research in the social sciences*, *111* Rand McNally Chicago.

Wigfield, A. & Eccles, J. S. (2000) Expectancy–Value Theory of Achievement Motivation. *Contemporary Educational Psychology*, 25(1), 68-81.

Wiig, K. M. (1997) Integrating intellectual capital and knowledge management. *Long Range Planning*, 30(3), 399-405.

William, G. Z. (2003) Business research methods. *Questionnaire Design,(Cengage learning, 2003), pg*, 329-360.

Wong, A., Wong, F. K. & Nadeem, A. (2009) Comparative roles of major stakeholders for the implementation of BIM in various countries, *Proceedings of the International Conference on Changing Roles: New Roles, New Challenges, Noordwijk Aan Zee, The Netherlands*.

Yang, C.C. & Lin, C. Y.Y. (2009) Does intellectual capital mediate the relationship between HRM and organizational performance? Perspective of a healthcare industry in Taiwan. *The International Journal of Human Resource Management*, 20(9), 1965-1984.

Yen, Y.F. (2013) The impact of bank's human capital on organizational performance: How innovation influences performance. *Innovation*, 15(1), 112-127.

Yin, R. (1994) Case study research: Design and methods . Beverly Hills. CA: Sage publishing.

Yin, R. K. (2003) Case study research: design and methods, Applied social research methods series. *Thousand Oaks, CA: Sage Publications, Inc. Afacan, Y., & Erbug, C.(2009). An interdisciplinary heuristic evaluation method for universal building design. Journal of Applied Ergonomics*, 40, 731-744.

Yuan, F. & Woodman, R. W. (2010) Innovative Behavior in the Workplace: The Role of Performance and Image Outcome Expectations. *Academy of Management Journal*, 53(2), 323-342.

Zahra, S. A. (1996) Technology strategy and financial performance: Examining the moderating role of the firm's competitive environment. *Journal of Business Venturing*, 11(3), 189-219.

Zahra, S. A. & George, G. (2002) Absorptive Capacity: A Review, Reconceptualization, And Extension. *Academy Of Management Review*, 27(2), 185-203.

Zhou, J. & George, J. M. (2001) When job dissatisfaction leads to creativity: Encouraging the expression of voice. *Academy of Management journal*, 44(4), 682-696.

APPENDIX A : REQUEST LETTER FOR ARCON NIGERIA

UNIVERSITY OF LIVERPOOL

School of Architecture,
School of the Arts
University of Liverpool
Leverhulme Building, Abercromby Square,
Liverpool
L69 7ZN, UK

Date__25/July/2015___

The Registrar,
Architects Registration Council of Nigeria (ARCON)
NULGE Building
26, Ajose Adeogun Street,
Off Augustus Aikhomu Street,
Utako, Abuja.
Sir,

REQUEST FOR A CONSENT LETTER TO CARRY OUT AN EDUCATIONAL RESEARCH FOR PHD ARCHITECTURE IN LIVERPOOL UNIVERSITY

I am a SA'ID ALKALI KORI with ID number 2001004259 , a PhD student under the supervision of Prof. Arto Kiviniemi and Dr. Tuba Kocaturk at School of Architecture, University of Liverpool, UK.

I wish to apply for a consent letter to carry out a research with the Architectural firms under your organization. It is an ethical requisite of carrying out a research study under the university of Liverpool, UK research guidelines.

Basically, the consent is requested for the following purposes:

1. To approach the architectural firms which are registered with your organization through an online-survey questionnaire.
2. To organize and carry out a case study with at least three (3) architectural firms in the country.
3. To organize and carry out two(2) research focus group with participants from among the representatives of architectural firms that are registered with your organization.
4. To consent and re-endorsed the use of the latest list of architectural firms and their addresses provided by the website of your organization as those that are registered with your organization.

The PhD research study is titled: "Business Model for Building Information Modelling (BIM) Adoption in Small and Medium Enterprise (SME) Architectural Firms in Nigeria". The aim of the study is to develop a conceptual business model framework for BIM adoption in SME architectural firms in emerging markets. Thus the study will mainly involved computer design related topics, Therefore, presumably the firms must have been using at least a computer in its practice to take part.

Currently, the AEC industry is facing a paradigm shift in its practice for which BIM is at the center. The underlying motivation for this shift is the improvements in productivity, product quality and sustainability that can be gained through prototyping of a building in a simulated system before construction begins. Such a shift is more than just a shift in the design delivery process or a change in the tools used; it is a social and cultural change

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as well, and requires a fundamental shift in the business culture. As a result, it is vital that practitioners understand the impact BIM may have on their business models and how to change their current modes of practice when incorporating BIM.

I made a prior MSc study on current state of the art of ICT in Nigeria context that instigated the exploration of the BIM adoption in small and medium enterprises (SME). Therefore, this research is developing a theoretical framework for exploring the culture and the issues impacting BIM adoption at the business level of SME architectural practices in emerging markets (within the context of Nigerian AEC Industry). The work will specifically involve assessing the current status of how ICT has altered the business settings in the SME architectural firms in Nigerian AEC industry.

You may However wish to refer to the participant information sheet below for more information regarding the study.

I will be glad to hear from you soonest and your help would be greatly appreciated, thank you very much for your time and cooperation.

Cordially,

Sa'id Alkali Kori (201004259)

If you have a concern about any aspect of this study, you should ask to speak to the researcher at anytime, who will do the best to answer your questions
The Research Student: Sa'id Alkali Kori; Tel: +44744314964; E-mail: s.a.kori@liverpool.ac.uk.
The Research Supervisor: Prof. Arto Kiviniemi; E-mail: A.kiviniemi@liverpool.ac.uk.
However, if you remain unhappy and wish to complain formally you can do this through contacting the Research Governance Officer at ethics@liv.ac.uk
When contacting the Research Governance Officer, please provide the study Title above for identification, the researcher's name above, and the details of the complaint you wish to make."

Participant Information Sheet:

1. *Invitation Paragraph*

You are being invited to participate in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to.

2. *What is the purpose of the study?*

Currently, the AEC industry is facing a paradigm shift for which BIM is at the center. The underlying motivation for this shift is the improvements in productivity, product quality and sustainability that can be gained through complete prototyping of a building in a simulated system before construction begins. Such a shift thought as a result of the ICT revolution is more than just a shift in the design delivery process or a change in the tools used; it is a social and cultural change as well, and requires a fundamental shift in business culture. As a result, it is vital that practitioners understand the impact BIM may have on their business models and how to change their current modes of practice when incorporating BIM.
A prior MSc study by the researcher on current state of art of ICT in Nigeria context instigated the exploration of the small and medium enterprise (SME) firm's adoption of the shift in the industry. Therefore, This research study presents a theoretical framework for exploring the culture and the issues impacting BIM adoption at the business level of SME architectural practices in emerging markets (within the context of Nigerian AEC Industry).
The work will specifically involve assessing the current status of how the shift of ICT has altered the business settings in the SME architectural firms in Nigerian AEC industry to establish the culture of practice and evaluate the different potential business systems evolving in such a process in order to predict and propose a theoretical business model framework of BIM adoption in SME architectural practice for emerging markets. Thus the survey will mainly involved computer design related topics, Therefore, presumably your firm must have been using at least a computer in its practice to take part.

3. *Why have I been chosen to take part?*

Version 6.0 July 2015

APPENDIX B1: APPROVAL LETTER FROM ARCON

ARCHITECTS REGISTRATION COUNCIL OF NIGERIA

(ARCON)

(ESTABLISHED BY CAP A. 19 ARCHITECTS (REGISTRATION ETC) ACT LFN 2004)

House 1A & 1B Dolphin Scheme II,
Behind Federal Secretariat Phase II,
P. O. Box 53895, Falomo, Ikoyi, Lagos.
Tel: 01-3424202

26, Ajose Adeogun Street,
(NULGE Building)
Off Augustus Aikhomu Street,
Utako Abuja.
Tel: 09-2917487

E-mail: registrar@arconigeria.org.ng
Website Address: www.arconigeria.org.ng

ARCON/48/Vol.II/117

2nd September, 2015

Mr. Sa'id Alkali Kori
School of Architecture
School of Arts
University of Liverpool
Leverhulme Building
Abercromby Square
Liverpool
L69 7 ZN, UK

RE: REQUEST FOR A CONSENT LETTER TO CARRY OUT AN EDUCATIONAL RESEARCH FOR PHD ARCHITECTURE IN LIVERPOOL UNIVERSITY

We acknowledge with thanks your letter dated 25th July, 2015 in respect of the above subject matter and attach herewith is the electronic copy of our current Register of Architectural Firms Entitled to practise in the Federal Republic of Nigeria.

We wish you all the best in your academic pursuit.

Arc. Umar Murnai, fnia
Registrar, ARCON

2

APPENDIX B2 : APPROVAL NOTIFICATION FROM UNIVERSITY OF LIVERPOOL

8/16/2017 Notification of ethics application - Kori, Sa'Id

Notification of ethics application

Halliwell-Bray, Alex

Thu 03/09/2015 13:35

To: Kiviniemi, Arto <kivi@liverpool.ac.uk>; Kori, Sa'Id <saidkori@liverpool.ac.uk>;

Cc: Arts Research <sotares@liverpool.ac.uk>;

Dear Arto and Sa'id,

I am pleased to inform you that the SOTA Ethics Committee has approved your application for ethical approval for your study. Details and conditions of the approval can be found below.

Ethics reference number:	SOTA34 1415
Committee name:	SOTA Ethics Committee
Review type:	Expedited
Title of study:	Business Model for building information modelling (BIM) adoption in small and medium enterprise (SME) architectural firms in Nigeria
Principal Investigator:	Prof Arto Kiviniemi
Student Investigator:	Mr Sa'id Kori
School/Institute:	School of the Arts
First reviewer:	Peter Goddard
Second reviewer:	Kay Richardson
Approval date:	3rd September 2015

The application was APPROVED subject to the following conditions:

Conditions

All serious adverse events must be reported to the Sub-Committee within 24 hours of their occurrence, via the Research Integrity and Governance Officer (ethics@liv.ac.uk).

This approval applies for the duration of the research. If it is proposed to extend the duration of the study as specified in the application form, the Sub-Committee should be notified. If it is proposed to make an amendment to the research, you should notify the Sub-Committee by following the Notice of Amendment procedure outlined at http://www.liv.ac.uk/media/livacuk/researchethics/notice%20of%20amendment.doc. If the named PI / Supervisor leaves the employment of the University during the course of this approval, the approval will lapse. Therefore please contact the Research Integrity and Governance Officer at ethics@liverpool.ac.uk in order to notify them of a change in PI / Supervisor.

Best wishes,

Alex

Alex Halliwell-Bray
Research & Finance Co-ordinator
School of the Arts
Faculty of Humanities and Social Sciences
19-23 Abercromby Square
Liverpool L69 7ZG
T: 0151-795 0271
E: A.Halliwell-Bray@liv.ac.uk
W: http://www.liv.ac.uk/arts/

https://owa.liv.ac.uk/owa/#viewmodel=ReadMessageItem&ItemID=AAMkADllNzhiZjlmLTAzZTItNGY4Zi1iY2RiLWYzMDc1YjlhNTdjYwBGAAAAAABKeW... 1/2

APPENDIX C: SURVEY QUESTIONAIRE SAMPLE

A QUESTIONARE SURVEY ON DIGITAL TECHNOLOGY ADOPTION IN SME FIRMS NIGERIA

PARTICIPANT INFORMATION AND CONSENT PAGE

BUSINESS MODEL FOR BUILDING INFORMATION MODELLING (BIM) ADOPTION IN SMALL AND MEDIUM ENTERPRISE (SME) ARCHITECTURAL FIRMS IN NIGERIA.

You are being invited to participate in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to.

2. What is the purpose of the study? Currently, the AEC industry is facing a paradigm shift for which BIM is at the centre. The underlying motivation for this shift is the improvements in productivity, product quality and sustainability that was gained through complete prototyping of building in a simulated environment before construction begins. Such a shift in thought as a result of the ICT revolution is more than just a shift in the design delivery process or a change in the tools used; it is a social and cultural change as well, and requires a fundamental shift in business culture. As a result, it is vital that practitioners understand the impact BIM may have on their business models and how to change their current modes of practice when incorporating BIM.

Prior study by the researcher on the current state of the art of digital technology in Nigeria instigated the desire to explore small and medium enterprise (SME) firm's adoption of Building Information Modelling. The proposed research study presents a theoretical framework for exploring the culture and the issues impacting BIM adoption by SME architectural firms business level in emerging markets (within the context of Nigerian AEC Industry).

The work will specifically involve assessing the current status of how the shift in ICT has altered SME architectural firm's business settings in Nigerian AEC industry. The study intends to establish the culture of practice and evaluate the different business models in order to propose a theoretical business model framework of BIM adoption for SME architectural firms in emerging markets. Thus the survey will mainly involve computer design related topics, it is expected that participating firms must have been using at least a computer in its practice to take part.

3. Why have I been chosen to take part? The study aims to examine the culture of practice toward digital technology adoption in Nigeria architectural firms. It involved registered firms by Architectural Registration Council of Nigeria (ARCON). Consent has been received from the council to carry out the research. The council provides the general data such as addresses and official contact details, which were used to contact each organization.

4. Do I have to take part? Your participation is entirely voluntary and you are free to withdraw at any time without giving any reason, without your rights being affected. In addition, should you not wish to answer any particular question or questions, you are free to decline.

5. What will happen if I take part? This study will require that you complete an online questionnaire survey along with any additional comments you want to make. Data for the survey will be collected using the online survey engine hosted by the university server. There are no risk associated in participating, as the survey has been approved by the Institutional review Board of the University of Liverpool.

You will be asked if you are willing to participate in other phases of the research and will be contacted in due course.

6. Expenses and/ or payment? No expense or payment are involved in this study

7. Are there any risks in taking part? No risk involved

8. Are there any benefits in taking part? We cannot promise that the study will help you directly but the information we get from the study will be used to develop a framework that can help BIM adoption in SME practices in the emerging markets. Moreover, the research is expected to provide information of the state of the art on how the shift of the ICT of the architectural firms is altering the business settings of the firms. The findings will help the discussion on future directions and developments within the industry and in the nation at large.

9. What if I am unhappy or if there is a problem? If you have a concern about any aspect of this study, you should ask to speak to the researcher at any time, who will do the best to answer your questions.

The Research Student: Sa'id Alkali Kori; Tel: +44744314964; E-mail: s.a.kori@liverpool.ac.uk.

The Research Supervisor: Prof. Arto Kiviniemi; E-mail: A.kiviniemi@liverpool.ac.uk.

However, if you remain unhappy and wish to complain formally, you can do this through contacting the Research Governance Officer at ethics@liv.ac.uk. When contacting the Research Governance Officer, please provide the study title above for identification, the researcher's name above, and the details of the complaint you wish to make.

10. Will my participation be kept confidential? All information that is collected during the course of the research will be kept strictly confidential, names and any other information you provide will be kept strictly confidential and will not be attributed to you or your organization either in raw data or in any of the publications.

The questionnaire responses are stored in the university's secure server. Only the researcher and his supervisor will have access to the data. Respondents contact details will be used in the next phase of the research, after which such data will be destroyed. The results of this research will be used for academic purpose only.

11. What will happen to the results of the study? The result of this research would be purely for educational use, specifically the researcher's PhD thesis and any publication related to it. After the thesis is accepted or the research will be otherwise ended, all the data will be securely destroyed.

12. What will happen if I want to stop taking part?

Since the answers will be collected anonymously and the collected data is not connected to the participants, there is no way to remove your data after you have finished your answers and sent them to the server. However, you can stop answering the questionnaire at any point and not send the answers you have given at that point. You can also choose the questions you want to answer and ignore the questions you don't want to answer. .

If you want to participate the next page will contain the final consent information for participants. After accepting its content you will be redirected to the actual questionnaire. Thank you

PARTICIPANT CONSENT SECTION

1. I confirm that I have read and understood the participant information section for this study. I have had the opportunity to consider the information, ask questions by email and have had these answered satisfactorily.
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my rights being affected. In addition, should I not wish to answer any particular question or questions, I am free to decline.
3. I understand that since the answers will be collected anonymously and the collected data is not connected to my contact information, there is no way to remove my data after I have finished my answers and sent them to the server. However, I can stop answering the questionnaire at any point and not send the answers I have given at that point. .
4. I understand and agree that once I submit my data it will become anonymised and I will therefore no longer be able to withdraw my data.
5. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research material, and my company or I will not be identified or identifiable in the report or reports that result from the research.
6. I understand that I must not take part if I am not using at least computer for any task in the firm I am representing.

You must tick yes to acknowledge that you fully understand and agree with the above statement before taking part.

I confirm YES to take part in this questionnaire study only	
If you wish to be contacted for other part of the study, please enter your contact information	Email Address :

SURVEY ON DIGITAL TECHNOLOGY ADOPTION OF SME FIRMS NIGERIA [PAGE 2/4]

SECTION A: BIM CAPABILITY

Identify what is the use of ICT facilities in office and design works of your firm	Tick one option
ICT not relevant in office	
ICT used for minor only office work	
ICT used for 2D Based Drafting and below only	
ICT used for Object-Based Modelling and below only	
ICT used for Model-Based Collaboration.	

SECTION B: HUMAN CAPITAL ASPECT

Our firm develops capability and motivation to adopt the current information technology we use because	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
The IT managers is on permanent basis				
The IT managers has higher education qualification				
The IT manger has previous IT experience.				
The IT managers has higher Job Satisfaction				

Our firm develops capability and motivation to adopt the current information technology we use because Our Top manager(s) has	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Strategic knowledge of innovation				
Non-resistance to change				
The ability to inspire others				
The quality of teamwork				

Our firm develops capability and motivation to adopt the current information technology we use because our	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Employees with regular training				
Employees with shared innovative value				
Employees with willingness to accept innovation				
Employees with self-motivations				

SECTION C: RELATIONSHIP CAPITAL ASPECT

Our firm derives motivation and network resource to adopt and use the current information technology facilties in the firm because of our	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Internal relation on effective communication flow				
Internal relation on confidence and trust,				
Internal relation on participative culture				
Internal relation on less uncertainty avoidance				

SURVEY ON DIGITAL TECHNOLOGY ADOPTION OF SME FIRMS NIGERIA [PAGE 3/4]

Our firm derives motivation and network resource to adopt and use the current information technology facilities because of our ability to interoperate with our external partners based on	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Technical interoperability				
Semantic interoperability				
Cultural interoperability				
Legal interoperability				

Our firm derives capability and network resource to adopt and use the current information technology facilities because there is a motivation from	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
The client system in the innovative environment				
The technology marketplace in the innovative environment				
The competitiveness in the innovative environment				
The government and regulatory system in the innovative environment				

Our firm derives motivation and network resource to adopt and use the current information technology facilities because we are motivated by the	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Outcome quality of its application				
Social reputational gains				
Employee's perception				

SECTION D: STRUCTURE CAPITAL ASPECT

Our firm develops capability and support to adopt and use the current information technology facilities because our system structure of operation has	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Flexible administrative system for innovation				
Effective knowledge management system				
Flexible policy system for innovation				
System for experimentation culture				

Our firm develops capability and support to adopt and use the current information technology facilities because we have of the following infrastructural facilities	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Availability of digital Hardware facilities				
Availability of digital Software facilities				
Availability of network facilities				
Availability of specific office space for ICT unit				
Availability of maintenance and upgrade facilities for technology				

SURVEY ON DIGITAL TECHNOLOGY ADOPTION OF SME FIRMS NIGERIA [PAGE 4/4]

Our firm develops capability and support to adopt and use the current information technology facilities because we have put in place the following processes and schemes	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Reward and incentive schemes for innovation				
In-house Training schemes for innovation				
Strategic Innovation management schemes				
Research and Development schemes				

SECTION E: KNOWLEDGE CAPITAL ASPECT

Our firm develops motivation and capability to adopt and use the current information technology facilities because of our Knowledge exploration capacity through	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Internal capability (employees, management etc)				
Business partners				
Institutions of learning				

Our firm develops motivation and capability to adopt and use the current information technology facilities because of our Knowledge exploitation capacity through	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Internal Channel; training. applications, trial etc.				
External channels ; collaborations, partnership etc.				

Our firm develops motivation and capability to adopt and use the current information technology facilities because of our Knowledge retention capacity through	Strongly Disagreed	Disagreed	Agreed	Strongly Agreed
Internal capacity				
Alliance and partnership with external partners				
Alliance and partnership with learning Institutions.				

Thank you,

APPENDIX D : CODING SHEET FOR THE SURVEY STUDY-SPSS GENERATED

CODE	TYPE	LABEL	VALUES/SCALE
IT_Permanent	Numeric	The IT managers is on permanent basis	{1.00, Strongly Disagree}...
IT_HighEdu	Numeric	The IT managers has higher education qualification	{1.00, Strongly Disagree}...
IT_Exp	Numeric	The IT manger previous IT experience.	{1.00, Strongly Disagree}...
IT_Job	Numeric	The IT managers has higher Job Satisfaction	{1.00, Strongly Disagree}...
TM_Knw	Numeric	Strategic knowledge of innovation	{1.00, Strongly Disagree}...
TM_NoReS	Numeric	Non-resistance to change	{1.00, Strongly Disagree}...
TM_Curiosity	Numeric	The ability to inspire others	{1.00, Strongly Disagree}...
TM_Team	Numeric	The quality of teamwork	{1.00, Strongly Disagree}...
REL_INTER1	Numeric	Internal relation of effective communication flow	{1.00, Strongly Disagree}...
REL_INTER2	Numeric	Internal relation of confidence and trust,	{1.00, Strongly Disagree}...
REL_INTER3	Numeric	Internal relation of participative culture	{1.00, Strongly Disagree}...
REL_INTER4	Numeric	Internal relation of less uuncertainty avoidance	{1.00, Strongly Disagree}...
REL_EXTER1	Numeric	Technical interoperability	{1.00, Strongly Disagree}...
REL_EXTER2	Numeric	Semantic interoperability	{1.00, Strongly Disagree}...
REL_EXTER3	Numeric	Cultural interoperability	{1.00, Strongly Disagree}...
REL_EXTER4	Numeric	Legal interoperability	{1.00, Strongly Disagree}...
REL_ENVIR1	Numeric	The client system in the innovative environment	{1.00, Strongly Disagree}...
REL_ENVIR2	Numeric	The technology marketplace in the innovative environment	{1.00, Strongly Disagree}...
REL_ENVIR3	Numeric	The competitiveness in the innovative environment	{1.00, Strongly Disagree}...
REL_ENVIR4	Numeric	The government and regulatory system in the innovative environment	{1.00, Strongly Disagree}...
REL_IMAGE1	Numeric	Functionality (outcome of BIM quality)	{1.00, Strongly Disagree}...
REL_IMAGE2	Numeric	Social dimension (reputational gains)	{1.00, Strongly Disagree}...
REL_IMAGE3	Numeric	Subjective dimensions (employees external perception)	{1.00, Strongly Disagree}...
STRU_SYSTEM1	Numeric	Flexible administrative system for innovation	{1.00, Strongly Disagree}...
STRU_SYSTEM2	Numeric	Effective knowledge management system	{1.00, Strongly Disagree}...
STRU_SYSTEM3	Numeric	Flexible policy system for innovation	{1.00, Strongly Disagree}...
STRU_SYSTEM4	Numeric	System for experimentation culture	{1.00, Strongly Disagree}...
STRU_INFRST1	Numeric	Availability of digital Hardware facilities	{1.00, Strongly Disagree}...
STRU_INFRST2	Numeric	Availability of digital Software facilities	{1.00, Strongly Disagree}...
STRU_INFRST3	Numeric	Availability of network facilities	{1.00, Strongly Disagree}...
STRU_INFRST4	Numeric	Availability of specific office space for ICT unit	{1.00, Strongly Disagree}...
STRU_INFRST5	Numeric	Availability of maintenance and upgrade facilities for technology.	{1.00, Strongly Disagree}...
STRU_PROCS1	Numeric	Reward and incentive schemes for innovation	{1.00, Strongly Disagree}...
STRU_PROCS2	Numeric	In-house Training schemes for innovation	{1.00, Strongly Disagree}...
STRU_PROCS3	Numeric	Strategic Innovation management schemes	{1.00, Strongly Disagree}...
STRU_PROCS4	Numeric	Research and Development schemes	{1.00, Strongly Disagree}...
KNW_EXPLORE1	Numeric	Internal inventive capacity	{1.00, Strongly Disagree}...
KNW_EXPLORE2	Numeric	Business Network absorptive capacity	{1.00, Strongly Disagree}...
KNW_EXPLORE3	Numeric	Uris absorptive capacity	{1.00, Strongly Disagree}...
KNW_EXPLOIT1	Numeric	Internal exploitation capacity	{1.00, Strongly Disagree}...
KNW_EXPLOIT2	Numeric	External exploitation capacity	{1.00, Strongly Disagree}...
KNW_RETEN1	Numeric	Internal transformative capacity	{1.00, Strongly Disagree}...
KNW_RETEN2	Numeric	connective capacity (alliance) with external partners	{1.00, Strongly Disagree}...
KNW_RETEN3	Numeric	connective capacity (alliance) with URIs	{1.00, Strongly Disagree}...

APPENDIX E: CASE STUDY QUESTIONS SAMPLE

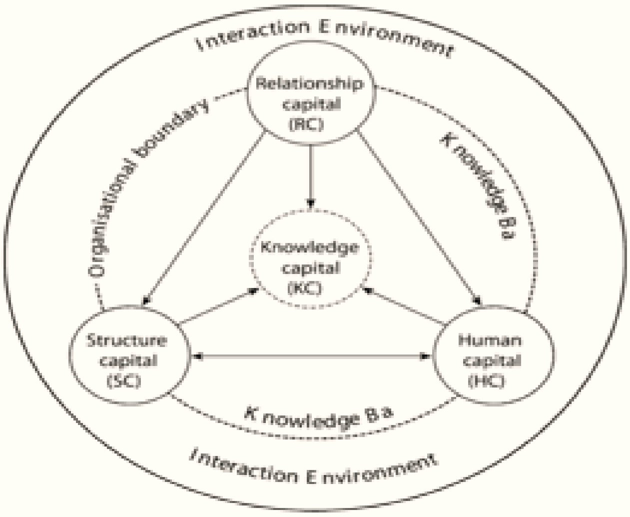
INTERVIEW QUESTIONS ON BIM ADOPTION PROCESS

PRELIMINARY AND DEMOGRAPHIC INFORMATIONS

THE INTERVIEW INFORMATION	
Date of Interview	
Venue of Interview (city)	
Time	
INFORMATION ABOUT THE FIRM.	
Name of Company	
Position of the interviewee	
Years since adopting BIM in practice	
Number of Employees in the company	
Average age of the employees	
Average age of the top manager(s)	
ON THE BIM COMPETENCE AND CAPABILITY	
What type of software are you using (please describe the function for each of the software in your firm)	1. BIMMEASURE (Measurement of BIM Models) 2. AUTOCAD. (Viewing Architectural Drawings and minor adjustments) 3. ARCHICAD (Viewing Architectural Drawings and minor adjustments)
What medium are you using in sharing design information in your firm. You may mention paper, 2D drawings, 3D model, BIM e.t.c	Within the firm 2D drawings, 3D model, BIM Outside the firm paper, 2D drawings, 3D model, BIM
Introduction of the BIM adoption process.	
1. Please describe briefly what was the goal of your firm in the BIM adoption? The goals are: i. To simplify workflow. ii. To improve efficiency. iii. To reduce use of paper in the office. iv. To comply with recent trends in the industry. 2. How do you set your strategic plans for the adoption process? The strategic plan was set by: i. Assessing IT capability of our company. ii. Assessing staff capacity and capability.	

iii. Assessing BIM capability of our partners.
iv. Drafting new work flow within our office.

The research framework explained.
Theory has shown that BIM adoption process in architectural firms is a knowledge base innovation, which occurs with the development of human capital, relationship capital, structure capital and knowledge capital.



These capitals development naturally occur in any of the BIM adoption process but lacked theoretical framework that can define them for appropriate deployment in the adoption process. In this interview, I will be asking you questions about how were you able to cultivate this capital and what are the important aspects of it's in the BIM adoption process.

SECTION ONE: HUMAN CAPITAL

Questions on how do you develop the motivation and capability of your firm's Human Capital to adopt and use BIM technology and create Business value?

A. IT Manager: What are the qualities and criteria you adopt to develop the motivation and capability of the IT manager in the firm in other to create BIM Business value?

B. Top Manager: What are the qualities and criteria you adopt to develop the motivation and capability of the Top manager in the firm in other to create BIM Business value?

C. Employees: What are the qualities and criteria you adopt to develop the motivation and capability of the Employees in the firm in other to create BIM Business value?

SECTION TWO: RELATIONSHIP CAPITALS

How do you develop your motivation and network resource from your relationship capital to adopt and use BIM technology and create Business value?

A. Internal relations: What are the steps and criteria you adopt to develop the motivation and network resource within your internal relationship of all the individuals of the firm in other to create BIM Business value?

B. External relations: What are the steps and criteria you adopt to develop the motivation and network resource within your external business and professional partners external to the firm in other to create BIM Business value?

C. Environmental relation: What are the steps and criteria you adopt to develop the motivation and network resource within interaction with the larger industry and the competitive environment outside the firm in other to create BIM Business value?

D. Image and reputation: What are the steps and criteria you adopt to develop the motivation and network resource though Image and reputation of the firm in other to create BIM Business value?

SECTION THREE: STRUCTURE CAPITALS

How do you develop your Capability and Support from the Structural capital of your firm capital to adopt and use BIM technology and create Business value?

A. Systems and Routines: What capabilities and structural resources do you ensure to possess within the systems and routines of the firm to support in creating BIM Business value?

B. Infrastructures and facilities: What capabilities and structural resources do you ensure to possess within the infrastructural and technology facilities of the firm to support in creating BIM Business value?

C. Processes and Schemes: What capabilities and structural resources do you ensure to possess through the processes and schemes in the firm to support in creating BIM Business value?

SECTION FOUR: KNOWLEDGE CAPITAL

How do you develop your knowledge Resource Capacity to adopt and use BIM technology and create Business value?

A. Knowledge exploration capacity: What channels and dimensions do you firm engaged with when identifying new ideas and knowledge to improve your BIM capability and Business value?

B. Knowledge Retention capacity: What channels and dimensions do your firm engaged with to ensure retention of new ideas and knowledge for continued use over time to improve your BIM capability and Business value?

C. Knowledge Exploitation capacity: What channels and dimensions do your firm engaged with to exploit the opportunities of the new ideas and knowledge toward creating BIM Business value?

APPENDIX F: CASE STUDY PAIRWISE COMPARISON TABLE

SECTION FIVE: PAIRWISE COMPARISON TABLE ON PRIORITY LEVEL OF COMPONENTS AND THE FOUR CAPITALS ASPECTS

Based on the above contribution

Mark your opinion about the relative importance of the factors given on the two sides of the scales (refer the scoring pattern). Please put tick marks on the number of your choice on each scale.

<u>**NB**</u>

- If the 'Left-Side Factor' is more important, put tick mark on the option toward the left of the scale.
- If the 'Left-Side Factor' and the 'Right-Side Factor' are equally important, put tick mark on centre portion (MIDDLE) of the scale.
- If the 'Right-Side Factor' is more important, put tick mark on the option toward the Right of the scale.

1. How relative important does the motivation and capability the following factors are to each on their influence toward success of BIM adoption in your firm?
2. **HUMAN CAPITAL COMPONENTS**

		Absolutely more important	Very strongly more important	Strongly more important	Slightly more important	Equally important	Slightly more important	Strongly more important	Very strongly more important	Absolutely more important	
		9	7	5	3	1	3	5	7	9	
1	IT manager										Top manager
4	IT manager										Employees
7	Top manager										Employees

How relative important does the network capability and resources the following factors are to each on their influence toward success of BIM adoption in your firm?

RELATIONSHIP CAPITAL COMPONENTS

		9	7	5	3	1	3	5	7	9	
1	Internal Relationships										External Relationships
2	Internal Relationships										Environmental relationships
3	Internal Relationships										Image and Reputation
4	External Relationships										Environmental relationships
5	External Relationships										Image and Reputation
6	Environmental relationships										Image and Reputation

How relative important does the resources from the following factors are to each other on their influence toward success of BIM adoption in your firm?

STRUCTURE CAPITAL COMPONENTS

		9	7	5	3	1	3	5	7	9	
1	Systems and Routines										Infrastructure and facilities
2	Systems and Routines										Process and Schemes
3	Infrastructure and facilities										Process and Schemes

How relative important does the absorptive capability of the following factors are to each other on their influence toward success of BIM adoption in your firm?

KNOWLEDGE CAPITAL COMPONENTS

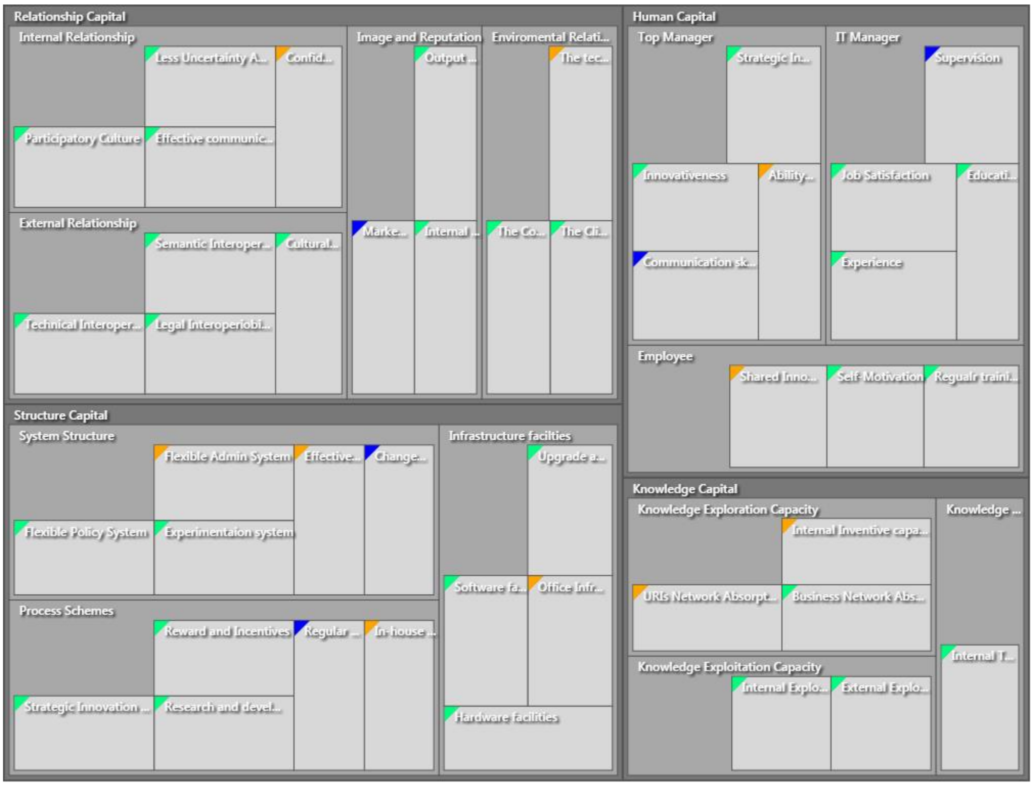
		9	7	5	3	1	3	5	7	9	
1	Exploration										Retention
2	Exploration										Exploitation
3	Retention										Exploitation

PRIORITY ON CAPITAL LEVEL

So, now that you are able to provide the level of relative importance of the above components under each capital, how relative important does the each of the capital have on each other on their influence toward success of BIM adoption in your firm?

	Left-Side Factor	9	7	5	3	1	3	5	7	9	Right-Side Factor
1	Human Capital										Relationship Capital
2	Human Capital										Structure Capital
3	Human Capital										Knowledge Capital
4	Relationship Capital										Structure Capital
5	Relationship Capital										Knowledge Capital
6	Structure capital										Knowledge Capital

APPENDIX G1: FIRM 1 CASE STUDY INTERVIEW AND PAIRWISE COMPARISON ANALYSIS.



KEY:

Green: Indicators accepted by survey and confirmed by the case study analysis

Orange: Indicators identified by literature but only confirmed by Case study analysis

Blue: New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 7.4.2:1: Hierarchy Chart: TreeMap generated by NVIVO software showing the analysis of data triangulation based on Case Study- Firm 1

Table 7.4.2:1 :Eigenvector Analysis showing the Relative Weighing Value for Human Capital Components based on Firm 1

	IT Manager	Top Manager	Employees	Priority point	Priority percentage	Rank
IT Manager	1	0.2	1.00	0.156	15.6	3
Top Manager	5.00	1	3.00	0.659	65.9	1
Employees	1.00	0.33	1	0.185	18.5	2

Number of comparisons = 3
Consistency Ratio CR = 3.0%
Principal Eigen value = 3.029
Eigenvector solution: 3 iterations, delta = 5.2E-8

Table 7.4.2:2 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Relationship Capital Components based on Firm 1

	Internal Relationship	External Relationship	Environmental Relationship	Image and Reputation	Priority point	Priority percentage	Rank
Internal Relationship	1.00	5.00	9.00	1.00	0.406	40.60%	2
External Relationship	0.20	1.00	5.00	0.14	0.103	10.30%	3
Environmental Relationship	0.11	0.20	1.00	0.11	0.036	3.60%	4
Image and Reputation	1.00	7.00	9.00	1.00	0.455	45.50%	1

Number of comparisons = 6
Consistency Ratio CR = 7.1%
Principal Eigen value = 4.193
Eigenvector solution: 5 iterations, delta = 5.1E-8

Table 7.4.2:3 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Structure Capital Components based on Firm 1

	System	Infrastructure	Process	Priority point	Priority percentage	Rank
System	1.00	0.20	3.00	0.202	20.20%	2
Infrastructure	5.00	1.00	5.00	0.701	70.10%	1
Process	0.33	0.20	1.00	0.097	9.70%	3

Number of comparisons = 3
Consistency Ratio CR = 14.1%
Principal eigen value = 3.135
Eigenvector solution: 5 iterations, delta = 2.0E-8

Table 7.4.2:4 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Knowledge Capital Components based on Firm 1

	Exploration	Retention	Exploitation	Priority point	Priority percentage	Rank
Exploration	1.00	5.00	3.00	0.637	63.70%	1
retention	0.20	1.00	0.33	0.105	10.50%	3
Exploitation	0.33	3.00	1.00	0.258	25.80%	2

Number of comparisons = 3
Consistency Ratio CR = 4.0%
Principal Eigenvalue = 3.039
Eigenvector solution: 4 iterations, delta = 3.7E-9

Table 7.4.2:5 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for the Four Aspects of Intellectual Capital based on Firm 1

	Human Capital	Relationship Capital	Structure capital	Knowledge Capital	Priority point	Priority percentage	Rank
Human Capital	1.00	5.00	0.33	5.00	0.294	29.40%	2
Relationship Capital	0.20	1.00	0.20	1.00	0.077	7.70%	3
Structure Capital	3.00	5.00	1.00	7.00	0.56	56.00%	1
Knowledge Capital	0.20	1.00	0.14	1.00	0.069	6.90%	4

Number of comparisons = 6
Consistency Ratio CR = 4.4%
Principal eigen value = 4.121
Eigenvector solution: 5 iterations, delta = 1.8E-8

APPENDIX G2: FIRM 2 CASE STUDY INTERVIEW AND PAIRWISE COMPARISON ANALYSIS.

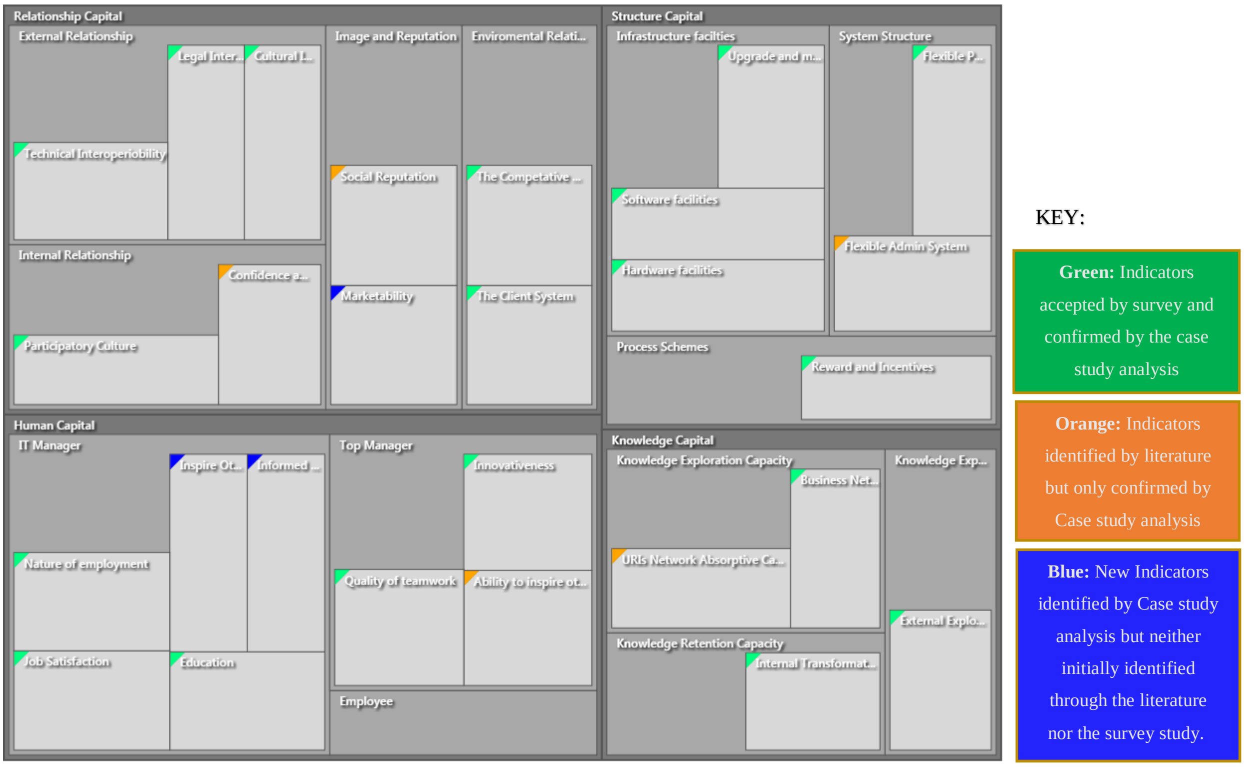


Figure 7.4.2:2: Hierarchy Chart generated by NVIVO software: TreeMap showing the analysis of data triangulation based on Case Study- Firm 2

Table 7.4.2:6: Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Human Capital Components based on Firm 2

	IT Manager	Top Manager	Employees	Priority point	Priority percentage	Rank
IT Manager	1	5.00	9.00	0.735	73.5	1
Top Manager	0.20	1	5.00	0.207	20.7	2
Employees	0.11	0.20	1	0.580	5.8	3

Number of comparisons = 3
Consistency Ratio CR = 12.2%
Principal Eigen value = 3.117
Eigenvector solution: 5 iterations, delta = 2.2E-8

Table 7.4.2:7 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Relationship Capital Components based on Firm 2

	Internal Relationship	External Relationship	Environmental Relationship	Image and Reputation	Priority point	Priority percentage	Rank
Internal Relationship	1.00	0.20	3.00	3.00	0.198	19.80%	2
External Relationship	5.00	1.00	9.00	5.00	0.623	62.30%	1
Environmental Relationship	0.33	0.11	1.00	0.20	0.048	4.80%	4
Image and Reputation	0.33	0.20	5.00	1.00	0.13	13.00%	3

Number of comparisons = 6
Consistency Ratio CR = 12.1%
Principal Eigen value = 4.330
Eigenvector solution: 6 iterations, delta = 2.6E-8

Table 7.4.2:8: Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Structure Capital Components based on Firm 2

	System	Infrastructure	Process	Priority point	Priority percentage	Rank
System	1.00	0.14	1.00	0.111	11.10%	2
Infrastructure	7.00	1.00	7.00	0.778	77.80%	1
Process	1.00	0.14	1.00	0.111	11.10%	2

Number of comparisons = 3
Consistency Ratio CR = 0.0%
Principal Eigenvalue = 3.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Table 7.4.2:9: Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Knowledge Capital Components based on Firm 2

	Exploration	Retention	Exploitation	Priority point	Priority percentage	Rank
Exploration	1.00	7.00	0.33	0.156	30.40%	2
retention	0.14	1.00	0.14	0.659	6.30%	3
Exploitation	3.00	7.00	1.00	0.185	63.30%	1

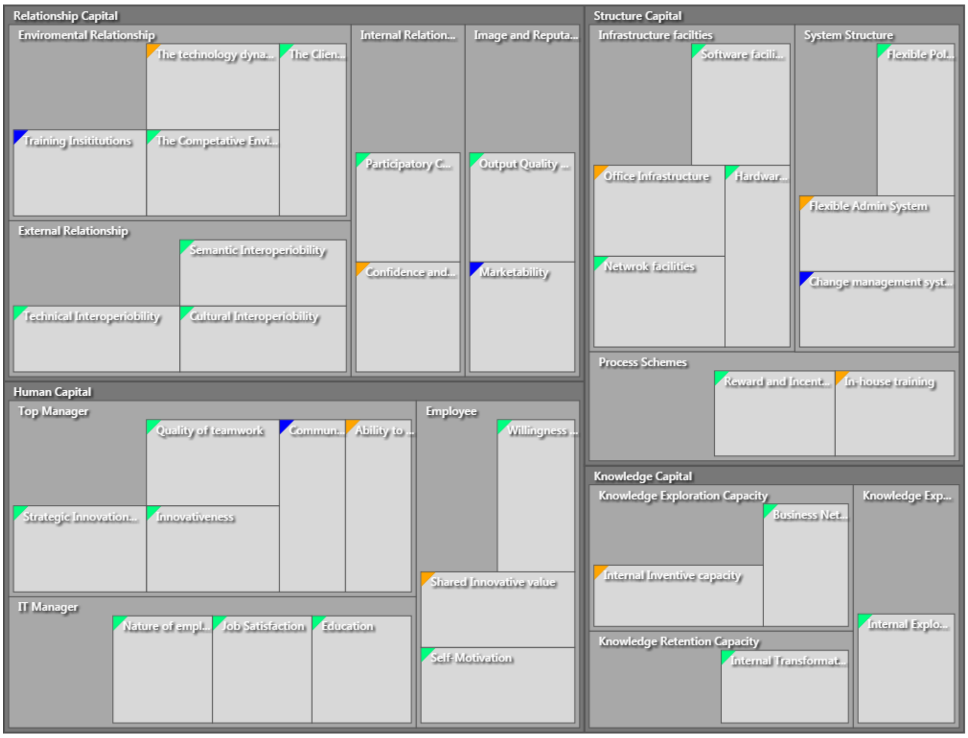
Number of comparisons = 3
Consistency Ratio CR = 14.1%
Principal Eigenvalue = 3.136
Eigenvector solution: 6 iterations, delta = 2.5E-9

Table 7.4.2:10 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for the Four Aspects of Intellectual Capital based on Firm 2

	Human Capital	Relationship Capital	Structure capital	Knowledge Capital	Priority point	Priority percentage	Rank
Human Capital	1	1	1	5	0.312	31.20%	1
Relationship Capital	1	1	1	5	0.312	31.20%	1
Structure Capital	1	1	1	5	0.312	31.20%	1
Knowledge Capital	0.2	0.2	0.2	1	0.062	6.20%	4

Number of comparisons = 6
Consistency Ratio CR = 12.1%
Principal Eigen value = 4.330
Eigenvector solution: 6 iterations, delta = 2.6E-8

APPENDIX G3: FIRM 3 CASE STUDY INTERVIEW AND PAIRWISE COMPARISON ANALYSIS.



KEY:

Green: Indicators accepted by survey and confirmed by the case study analysis

Orange: Indicators identified by literature but only confirmed by Case study analysis

Blue: New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 7.4.2:3: Hierarchy Chart generated by NVIVO software.: TreeMap showing the analysis of data triangulation based on Case Study-Firm 3

Table 7.4.2:11 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Human Capital Components based on Firm 3

	IT Manager	Top Manager	Employees	Priority point	Priority percentage	Rank
IT Manager	1	1.00	1.00	0.319	31.9	2
Top Manager	1.00	1	0.33	0.221	22.1	3
Employees	1.00	3.00	1	0.460	46.0	1

Number of comparisons = 3
Consistency Ratio CR = 14.1%
Principal Eigenvalue = 3.136
Eigenvector solution: 5 iterations, delta = 4.4E-8

Table 7.4.2:12 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Relationship Capital Components based on Firm 3

	Internal Relationship	External Relationship	Environmental Relationship	Image and Reputation	Priority point	Priority percentage	Rank
Internal Relationship	1.00	3.00	9.00	3.00	0.509	50.90%	1
External Relationship	0.33	1.00	5.00	3.00	0.271	27.10%	2
Environmental Relationship	0.11	0.20	1.00	0.11	0.39	3.90%	4
Image and Reputation	0.33	0.33	9.00	1.00	0.182	18.20%	3

Number of comparisons = 6
Consistency Ratio CR = 13.2%
Principal Eigenvalue = 4.359
Eigenvector solution: 7 iterations, delta = 2.4E-8

Table 7.4.2:13 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Structure Capital Components based on Gamma Firm

	System	Infrastructure	Process	Priority point	Priority percentage	Rank
System	1.00	0.20	5.00	0.207	20.70%	2
Infrastructure	5.00	1.00	9.00	0.735	73.50%	1
Process	0.20	0.11	1.00	0.58	5.80%	3

Number of comparisons = 3
Consistency Ratio CR = 12.2%
Principal Eigenvalue = 3.117
Eigenvector solution: 5 iterations, delta = 2.2E-8

Table 7.4.2:14 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Knowledge Capital Components based on Firm 3

	Exploration	Retention	Exploitation	Priority point	Priority percentage	Rank
Exploration	1.00	3.00	0.33	0.281	28.10%	2
retention	0.33	1.00	0.33	0.135	13.50%	3
Exploitation	3.00	3.00	1.00	0.584	58.40%	1

Number of comparisons = 3
Consistency Ratio CR = 14.1%
Principal Eigenvalue = 3.136
Eigenvector solution: 5 iterations, delta = 4.6E-8

Table 7.4.2:15 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for the Four Aspects of Intellectual Capital based on Firm 3

	Human Capital	Relationship Capital	Structure capital	Knowledge Capital	Priority point	Priority percentage	Rank
Human Capital	1.00	7.00	5.00	7.00	0.643	64.30%	1
Relationship Capital	0.14	1.00	0.33	3.00	0.097	9.70%	3
Structure Capital	0.20	3.00	1.00	5.00	0.209	20.90%	2
Knowledge Capital	0.14	0.33	0.20	1.00	0.051	5.10%	4

Number of comparisons = 6
Consistency Ratio CR = 8.8%
Principal Eigenvalue = 4.240
Eigenvector solution: 6 iterations, delta = 1.5E-9

APPENDIX G4: FIRM 4 CASE STUDY INTERVIEW AND PAIRWISE COMPARISON ANALYSIS.

KEY:

Green: Indicators accepted by survey and confirmed by the case study analysis

Orange: Indicators identified by literature but only confirmed by Case study analysis

Blue: New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 7.4.2:4: Hierarchy Chart generated by NVIVO software.: TreeMap showing the analysis of data triangulation based on Case Study- Firm 4

Table 7.4.2:16 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Human Capital Components based on Firm 4

	IT Manager	Top Manager	Employees	Priority point	Priority percentage	Rank
IT Manager	1	5.00	3.00	0.659	65.9%	1
Top Manager	0.20	1	1.00	0.156	15.6%	3
Employees	0.33	1.00	1	0.185	18.5%	2

Number of comparisons = 3
Consistency Ratio CR = 14.1%
Principal Eigenvalue = 3.136
Eigenvector solution: 5 iterations, delta = 4.4E-8

Table 7.4.2:17 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Relationship Capital Components based on Firm 4

	Internal Relationship	External Relationship	Environmental Relationship	Image and Reputation	Priority point	Priority percentage	Rank
Internal Relationship	1.00	3.00	7.00	0.33	0.292	29.20%	2
External Relationship	0.33	1.00	5.00	0.33	0.153	15.30%	3
Environmental Relationship	0.14	0.20	1.00	0.14	0.45	4.50%	4
Image and Reputation	3.00	3.00	7.00	1.00	0.510	51.10%	1

Number of comparisons = 6
Consistency Ratio CR = 8.4%
Principal Eigen value = 4.228
Eigenvector solution: 6 iterations, delta = 7.0E-9

Table 7.4.2:18 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Structure Capital Components based on Firm 4

	System	Infrastructure	Process	Priority point	Priority percentage	Rank
System	1.00	3.00	3.00	0.584	58.40%	1
Infrastructure	0.33	1.00	3.00	0.281	28.10%	2
Process	0.33	0.33	1.00	0.135	13.50%	3

Number of comparisons = 3
Consistency Ratio CR = 14.1%
Principal Eigenvalue = 3.136
Eigenvector solution: 5 iterations, delta = 4.6E-8

Table 7.4.2:19 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Knowledge Capital Components based on Firm 4

	Exploration	Retention	Exploitation	Priority point	Priority percentage	Rank
Exploration	1	1	1	0.333	33.30%	1
retention	1	1	1	0.333	33.30%	1
Exploitation	1	1	1	0.333	33.30%	1

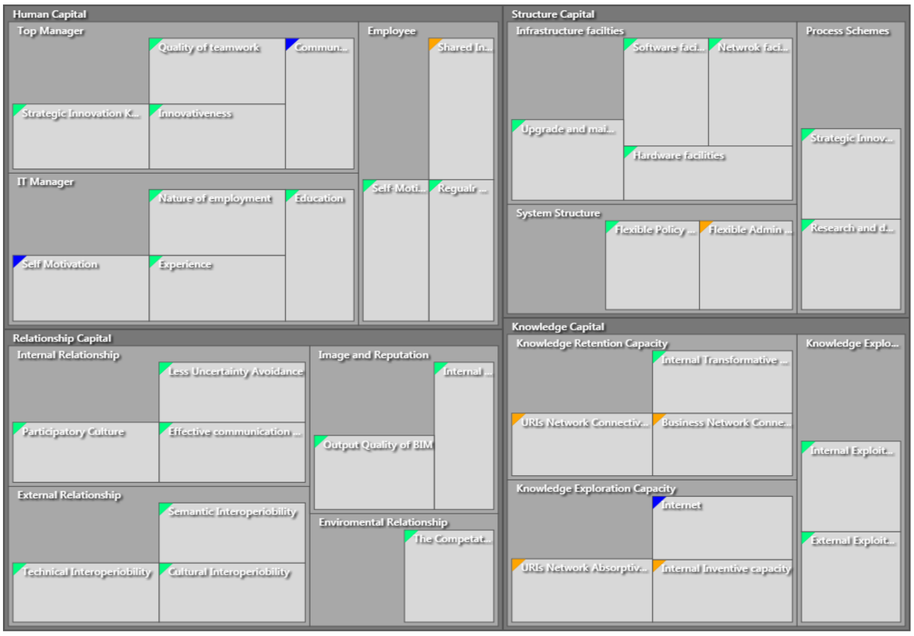
Number of comparisons = 3
Consistency Ratio CR = 0.0%
Principal eigenvalue = 3.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Table 7.4.2:20 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for the Four Aspects of Intellectual Capital based on Delta Firm

	Human Capital	Relationship Capital	Structure capital	Knowledge Capital	Priority point	Priority percentage	Rank
Human Capital	1.00	1.00	5.00	5.00	0.468	46.80%	1
Relationship Capital	1.00	1.00	3.00	1.00	0.293	28.30%	2
Structure Capital	0.20	0.33	1.00	1.00	0.102	10.20%	4
Knowledge Capital	0.20	1.00	1.00	1.00	0.147	14.70%	3

Number of comparisons = 6
Consistency Ratio CR = 9.7%
Principal Eigen value = 4.264
Eigenvector solution: 6 iterations, delta = 7.4E-9

APPENDIX G5: FIRM 5: CASE STUDY INTERVIEW AND PAIRWISE COMPARISON ANALYSIS.



KEY:

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Orange: Indicators identified by literature but only confirmed by Case study analysis

Blue: New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 7.4.2:5: Hierarchy Chart generated by NVIVO software.: TreeMap showing the analysis of data triangulation b

Table 7.4.2:21 :Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Human Capital Components based on Firm 5

	IT Manager	Top Manager	Employees	Priority point	Priority percentage	Rank
IT Manager	1	3.00	1.00	0.429	42.9	1
Top Manager	0.33	1	0.33	0.143	14.3	3
Employees	1.00	3.00	1	0.429	42.9	1

Number of comparisons = 3
Consistency Ratio CR = 0.0%
Principal Eigenvalue = 3.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Table 7.4.2:22 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Relationship Capital Components based on Firm 5

	Internal Relation ship	External Relation ship	Environ mental Relation ship	Image and Reputatio n	Priority point	Priority percentag e	Rank
Internal Relationship	1.00	5.00	5.00	5.00	0.602	60.20%	1
External Relationship	0.20	1.00	3.00	3.00	0.208	20.80%	2
Environmental Relationship	0.20	0.33	1.00	3.00	0.12	12.00%	3
Image and Reputation	0.20	0.33	0.33	1.00	0.069	6.90%	4

Number of comparisons = 6
Consistency Ratio CR = 11.3%
Principal Eigen value = 4.309
Eigenvector solution: 6 iterations, delta = 7.9E-9

Table 7.4.2:23 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Structure Capital Components based on Firm 5

	System	Infrastructure	Process	Priority point	Priority percentage	Rank
System	1.00	1.00	3.00	0.429	42.90%	1
Infrastructure	1.00	1.00	3.00	0.429	42.90%	1
Process	0.33	0.33	1.00	0.143	14.30%	3

Number of comparisons = 3
Consistency Ratio CR = 0.0%
Principal Eigenvalue = 3.000
Eigenvector solution: 1 iterations, delta = 3.1E-33

Table 7.4.2:24 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Knowledge Capital Components based on Firm 5

	Exploration	Retention	Exploitation	Priority point	Priority percentage	Rank
Exploration	1.00	0.33	3.00	0.281	28.10%	2
retention	3.00	1.00	3.00	0.584	58.40%	1
Exploitation	0.33	0.33	1.00	0.135	13.50%	3

Number of comparisons = 3
Consistency Ratio CR = 14.1%
Principal Eigenvalue = 3.136
Eigenvector solution: 5 iterations, delta = 4.6E-8

Table 7.4.2:25 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for the Four Aspects of Intellectual Capital based on Firm 5

	Human Capital	Relation ship Capital	Structure capital	Knowled ge Capital	Priority point	Priority percenta ge	Rank
Human Capital	1.00	3.00	5.00	7.00	0.551	55.10%	1
Relationship Capital	0.33	1.00	3.00	7.00	0.274	27.40%	2
Structure Capital	0.20	0.33	1.00	5.00	0.131	13.10%	3
Knowledge Capital	0.14	0.14	0.20	1.00	0.044	4.40%	4

Number of comparisons = 6
Consistency Ratio CR = 8.8%
Principal Eigen value = 4.240
Eigenvector solution: 6 iterations, delta = 2.6E-9

APPENDIX G6: FIRM 6: CASE STUDY INTERVIEW AND PAIRWISE COMPARISON ANALYSIS.

KEY:

Green: Indicators accepted by survey and confirmed by the case study analysis

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Blue: New Indicators identified by Case study analysis but neither initially identified through the literature nor the survey study.

Figure 7.4.2:6: Hierarchy Chart generated by NVIVO software.: TreeMap showing the analysis of data triangulation based on Case Study-Theta Firm

Table 7.4.2:26 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Human Capital Components based on Theta Firm

	IT Manager	Top Manager	Employees	Priority Point	Priority percentage	Rank
IT Manager	1	0.20	1.00	0.143	14.3	2
Top Manager	5.00	1	5.00	0.714	71.4	1
Employees	1.00	0.20	1	0.143	14.3	2

Number of comparisons = 3
Consistency Ratio CR = 0.0%
Principal Eigen value = 3.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Table 7.4.2:27 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Relationship Capital Components based on Theta Firm

	Internal Relationship	External Relationship	Environmental Relationship	Image and Reputation	Priority point	Priority percentage	Rank
Internal Relationship	1.00	3.00	3.00	3.00	0.476	47.60%	1
External Relationship	0.33	1.00	3.00	3.00	0.275	27.50%	2
Environmental Relationship	0.33	0.33	1.00	0.33	0.092	9.20%	4
Image and Reputation	0.33	0.33	3.00	1.00	0.158	15.80%	3

Number of comparisons = 6
Consistency Ratio CR = 11.3%
Principal Eigen value = 4.309
Eigenvector solution: 6 iterations, delta = 2.0E-8

Table 7.4.2:28 : Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Structure Capital Components based on Theta Firm

	System	Infrastructure	Process	Priority point	Priority percentage	Rank
System	1.00	0.20	1.00	0.156	15.60%	3
Infrastructure	5.00	1.00	3.00	0.659	65.90%	1
Process	1.00	0.33	1.00	0.185	18.50%	2

Number of comparisons = 3
Consistency Ratio CR = 3.0%
Principal eigenvalue = 3.029
Eigenvector solution: 3 iterations, delta = 5.2E-8

Table 7.4.2:29 ; Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for Knowledge Capital Components based on Theta Firm

	Exploration	Retention	Exploitation	Priority point	Priority percentage	Rank
Exploration	1.00	7.00	5.00	0.731	73.10%	1
retention	0.14	1.00	0.33	0.081	8.10%	3
Exploitation	0.20	3.00	1.00	0.188	18.80%	2

Number of comparisons = 3
Consistency Ratio CR = 6.8%
Principal Eigenvalue = 3.065
Eigenvector solution: 4 iterations, delta = 1.8E-8

Table 7.4.2:30: Matrix Table for the Eigenvector Analysis showing the Relative Weighing Value for the Four Aspects of Intellectual Capital based on Theta Firm

	Human Capital	Relationship Capital	Structure capital	Knowledge Capital	Priority point	Priority percentage	Rank
Human Capital	1.00	3.00	5.00	7.00	0.571	57.10%	1
Relationship Capital	0.33	1.00	3.00	3.00	0.241	24.10%	2
Structure Capital	0.20	0.33	1.00	3.00	0.124	12.40%	3
Knowledge Capital	0.14	0.33	0.33	1.00	0.065	6.50%	4

Number of comparisons = 6
Consistency Ratio CR = 5.1%
Principal Eigen value = 4.140
Eigenvector solution: 5 iterations, delta = 7.4E-9